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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF LONDON.

SECOND SERIES.

VOLUME IV.

Quod si cui mortalium cordi et curæ sit, non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare ; atque non disputando adversarium, sed opere naturam vincere ; denique non belle et probabiliter opinari, sed certo et ostensive scire ; tales, tanquam veri scientinarum filii, nobis (si videbitur) se adjungant.

Novum Organum, Præfatio.

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*** The Binder is directed to place the Lists of Officers and Council immediately after the Title Page, in the order of their Dates; and he is to place Plate X. b. *before* Plate X. a., that both may fold out, and be examined at the same time.

ERRATA ET CORRIGENDA.

Page 106, line 5, *for* No. 1.) illustrates *read* No. 1. and X. b. fig. 1. illustrate

—— 107, — 17, *after* No. 1. *insert* and Plate X. b. fig. 1.

—— 108, Note *, *for* Section, Plate X. a. No. 1. *read* Sections, Plate X. a. No. 1. and X. b. fig. 1.

—— 111, line 3 from bottom, *for* at *read* from

—— 112, — 23, *for subcristatus* read *cristatus*; *and add* Plate XI. fig. 23.—See Appendix A. p. 337.

—— 113, — 15, *for Hamites* aculeatus *read Hamites* spiniger

—— — — 9 from bottom, *add the words* also at Blackdown, Devon, Plate XVIII. p. 242.

—— 119, — 9 from bottom, *for* Siphonaria, *read* Siphonia

—— 130, — 20, *for* XXI. f. 7. *read* XXIII. fig. 7.

—— 131, — 14, for *Trochus*, read *Pleurotomaria*

—— 138, The thickness of the beds represented in the *Wood-cut* differs in some respects from those of the *List*, p. 139; the latter are the more correct.

—— 143, line 22, *dele* is

—— 153, — 3, *for* striata *read* gigantea

—— 164, — 3, *for* fig. 2. *read* fig. 3.

—— — — 4, *for* No. 5. *read* No. 6.

—— 167, — 11 from bottom, *for* (b.) *read* (β.)

—— — — 9 from bottom, *for* (b.) *read* (β.)

—— — — 9 from bottom, for *fluviorum* read *vivipara*

—— 168, — 1, *for* (2. b. and 2. e.) *read* 2. β. and 2. ε.

—— — — 8, *for* 12 *read* 10?

—— — — 11, *for* 2. a. *read* 2. α.

—— — last line, *add* p. 186, *read* (95.) p. 186.

—— 181, line 15, *for* Pippingford *read* Peppingford-Park

—— — — 21, for *Odontopteris* read *Sphenopteris*

—— 182, — 13 from bottom, *for* No. 6. *read* No. 7.

—— 195, — 14, 15, 17, from bottom, for *Gryphæa* read *Exogyra*

—— 203, — 3, for *Seligrimus* read *Selliguinus*

—— 204, — 2, *insert* "*Anomia* convexa. Plate XIV. fig. 7. Shore East of Shanklin Chine. See p. 338."

—— — — 25, after *Ostrea* carinata *insert* "Ostrea retusa, Plate XIV. fig. 4.; from Atherfield, in the Lower greensand."

—— 214, last line, for VIII. *read* IX.

—— 225, line 14, *dele* and

—— 230, — 9, *for* XX. *read* XXII.

Page 231, line 24, *for* tricristata *read* triserrata

—— 234, — 6, *after* thus: *insert* "(see Plate X. a. No. 11, and X. b. fig. 9.)"

—— 241, — 19, 2nd column, } *for* Stutchburiensis
—— 342, — 2, from bottom, } *read* Stutchburianus
and Descript. of Pl. XVIII. fig. 1.

—— 242, — 9, first column, *for* megastrema *read* megatrema

—— — — 5, second column, *add the words* "also from Eastware Bay, in Kent; see p. 114, line 32."

—— 252, — 15, *for* 4 feet to 7 feet *read* 4 to 7

—— 259, — 19, *for* in *read* or

—— 260, — 8, *for* Berston *read* Benston

—— 262, — 26, *for* South *read* North

—— — — 32, *for* between Gin Cross *read* from Gore Cross

—— 273, — 6 from bottom, *for* Aptychus *read Trigonellites*

—— 292, — 23 and 30, *for* Aptychus *read Trigonellites*

—— 297, — 10 from bottom, *dele the semicolon after* suboolitic

—— 298, — 20, for *Potamides carinatum* read *Potamides*? (a new species.)

—— 300, — 5 from bottom, *for* 286 *read* 206

—— 302, — 19, for *Aptychus* (Von Meyer),—read "*Trigonellites*, (Parkinson); *Ichthyosiagones*, (Rüppell); *Aptychus*, (Von Meyer.)"

—— 303, — 5, *for* 206. *read* 286.

—— 304, — 16 from bottom, *for* masses *read* matter

—— — — 24, *for* masses *read* matter

—— 305, — 9, *dele the word* "chalk"

—— 309, — 4, *note* †, *for* R. C. *read* C. B.

—— 316, — 6 from bottom, for *Aptychus* read *Trigonellites*

—— 324, — 8, *for* (168.) p. 326. *read* (167.) and (168.) pp. 326. and 329.

—— 339, — 9, for *gigantea read* striata

—— 352, In the reference connected with *Pentacrinites scalaris*, for fig. 2. *read* fig. 4.

Tables 353, After *Gastrochæna*, insert "sp. doubtful.—In perforations in dicotyledonous (silicified) wood;—*Gault*, east of Folkstone."

—— 355, In the reference *Cytherea* subrotunda, *for* Pl. XXII. 2. *read* Plate XVII. 2.

—— 355, After *Cyclas media* insert "C—— *media*, a gibbose variety, Pl. XXI. fig. 11. (*Hastings-sand*; Sussex, 177.—*Purbeck strata*; S. Wilts, 259.)"

—— 358, *note, dele* ?? *after the word* adjective

I.—*On the Geology of the Neighbourhood of Weymouth and the adjacent Parts of the Coast of Dorset.*

By the Rev. W. BUCKLAND, D.D. F.G.S. F.R.S.
(professor of geology and mineralogy in the university of oxford.)
And H. T. De la BECHE, Esq. F.G.S. F.R.S. &c.

[Read April 2 and 16, 1830.]

FEW parts of the world present in a small compass so instructive a series of geological phænomena as those which are displayed in the vertical cliffs of the south coast of England. An important portion of this coast, including the Isle of Wight and the Isle of Purbeck, has been well described by Mr. Webster*, and subsequently illustrated by Dr. Fitton†. In the Second Series of the Geological Transactions‡, Mr. De la Beche has published sections of the coast from Bridport Harbour to Sidmouth; and in the same volume Dr. Buckland has given drawings of the cliffs from Sidmouth to Beer Head, and from Lyme Regis to the Isle of Portland§. The geological history of the neighbourhood of Weymouth has been partially illustrated by Prof. Sedgwick in the Annals of Philosophy ||; and it will be the object of this paper to supply its full details, illustrated by a map and sections; beginning our observations at the point where Mr. Webster's sections end, viz., at the Promontory of White Nore, about eight miles E.N.E. of the town of Weymouth, and continuing them to Weymouth and Portland, and thence westward along the Chesil Bank to the cliffs west of Lyme Regis.

To our representations of the coast we shall add many inland sections of the adjacent district, including all the strata which occupy that portion of the south frontier of the county of Dorset which lies between the great south

* See Sir H. Englefield's History of the Isle of Wight; the Geological Transactions, First Series, vol. ii. p. 161—254; and Second Series, vol. ii. Part I. p. 37—44: also Annals of Philosophy, vol. xxv. p. 33—51.

† Annals of Philosophy, Nov. 1824, vol. lxiv. p. 376.

‡ Geological Transactions, Second Series, vol. i. Part I. Pl. VIII. § Ibid. Plate XIV.

|| Annals of Philosophy, 1826, vol. xxvii. p. 346.

escarpment of the chalk downs and the sea. We shall designate this tract by the general appellation of the Weymouth District: it is a tract of no small importance in the geological history of England:—

1. From its position near the south-western termination of several principal formations of this island, including tertiary strata, chalk, greensand, Purbeck and Portland beds, several members of the oolite formation, and lias.

2. As exhibiting a coast section which forms an interesting object of comparison with the north-eastern terminations of the same strata on the coast of Yorkshire, which have recently been so well described by Mr. Phillips*, and with their appearance across the Channel on the coast of Normandy, the details of which have been described by Mr. De la Beche in the Geological Transactions†, and subsequently by M. de Caumont in his Essay on the Department of Calvados‡.

3. As affording remarkable examples of violent disturbances which have affected all these strata since the period of their consolidation; producing elevations, depressions, fractures, and denudations, connected and continuous with those which have operated so extensively in Purbeck and the Isle of Wight, and through the wealds of Sussex and Kent.

We shall take a short review of the general physical features of this district before we enter upon geological details. It will be seen by reference to our map§, which is on the same scale as the Ordnance Survey, that the physical features of the coast are:—1. On the east a range of high cliffs extending from the chalk of White Nore to the flat marsh lands of Lodmore near Weymouth. 2. The marsh lands of Lodmore, divided only by a bank of pebbles from the waters of Weymouth Bay. 3. A low range of cliffs, extending from Weymouth Harbour to Portland Ferry. 4. The remarkable accumulation of pebbles called the Chesil Bank, extending from the northern extremity of Portland about sixteen miles north-westward to Burton Castle, and causing the sea to be separated from the main land along nearly half this district by a backwater called the Fleet. 5. A succession of cliffs rising gradually from Burton towards the west till they attain their highest elevation of about 600 feet in the summit of the Golden Cap Hill, between Bridport and Charmouth.

The physical features of the interior divide it into two distinct compartments, which we shall call the Vale of Weymouth and the Vale of Bredy.

The Vale of Bredy is bounded on the north and east by lofty escarpments of

* Illustrations of the Geology of Yorkshire, by John Phillips, Esq. F.G.S. York, 1829.

† Geological Transactions, Second Series, vol. i. Part I. p. 40—47.

‡ *Essai sur la Topographie Géognostique du Département du Calvados*, par M. de Caumont. Caen, 1828.

§ Plate I.

the chalk downs; on the south by Abbotsbury Castle, and a lower range which slopes from thence continuously to Burton Castle; on the west it is separated by some hills of moderate elevation from the valley of Bridport.

Of the Vale of Weymouth the following are the three most prominent features:—

1st, The lofty escarpment of the Ridgeway which bounds it on the north, running nearly in a straight line about twelve miles from east to west.

2nd, The elevated and inclined plane of limestone which constitutes the Isle of Portland, and terminates this district towards the south.

3rd, Between this elevated Ridgeway and Portland is a space somewhat triangular, composed of an alternation of low and nearly parallel, narrow ridges and narrow valleys, which are terminated successively on the west by the Chesil Bank, and on the east by Portland Road and Weymouth Bay; these all diminish in length successively, as their position is nearer to the south, until the most southerly of them terminates in the sea at Portland Ferry.

These ridges and valleys constitute a series of narrow belts, which are crossed nearly at right angles by the road from Dorchester to Weymouth; we shall therefore designate these belts by the names of the villages that stand upon or nearest to them: thus the names of Upway, Upway Street, Broadway, Nottington, and Radipole, will indicate five successive belts, composed of five distinct and successive formations; namely, Portland stone, Kimmeridge clay, Oxford oolite, Oxford clay, and forest marble,—all dipping north towards the base of the escarpment of the Ridgeway chalk: nearly in the centre of this belt of forest marble the dip changes suddenly towards the south; and the same succession of strata is repeated, dipping in an opposite direction southwards, and disposed in corresponding belts, which may be designated by the names of Melcombe, Wyke Regis, Portland Ferry, and Portland Island. The formations superior to the Portland beds, if they exist south of the island, are covered by the sea exterior to the Bill of Portland. At the Race of Portland the agitation of the water is caused by the obstruction which the subjacent mass of Portland stone offers to the tidal currents. The line of section fig. 1,* exhibits the general structure of this district.

The forest marble†, with its clays and cornbrash, constituting the lowest strata which rise to the surface, forms a double, central belt, elevated, as Mr.

* Plate II.

† The forest marble and cornbrash are so closely united throughout this district, that, except in cases of minute local description, it will be most convenient to include them and their subordinate clays under the common appellation of forest marble.

Conybeare has stated*, into the form of an arch or saddle, on each side of which the superior strata repose in corresponding order of succession, having their dips respectively conformable to the north and south dips of the sides of the arch, whilst their direction or line of bearing is nearly east and west, and parallel to the axis of this central arch. Thus, on each side of our axis or anticlinal line of forest marble, the Oxford clay reposes conformably, and constitutes two parallel valleys, which extend from the sea in Weymouth Bay to the Chesil Bank. To these succeed two similar parallel ridges of the Oxford oolite formation, which are again overlaid by two parallel belts of Kimmeridge clay, on which are still further superimposed two distinctly characterized deposits of Portland stone; and on the north side only, above the Portland stone we find strata belonging to the Purbeck series, to the green sand, the chalk, and plastic clay.

The superficial breadth of the belts on each side of the anticlinal line is in the inverse ratio of their dip; and as this dip is most rapid on the north side, the surface of the northern belts is less broad than that of the corresponding belts on the south side.

Having taken this general view of the structure of the coast of Dorset, we will again examine its component parts in a descending order, and point out in regular succession the history and peculiar circumstances of each formation of which it is composed, beginning from the eastern extremity at White Nore, and thus connecting it immediately with the observations of Mr. Webster.

Tertiary Deposits.—Plastic Clay, &c.

It is well known from the maps of Mr. Webster† and Mr. Greenough‡, that the tertiary strata which fill the chalk basin of Hants and Dorset find their western termination about three miles east of Dorchester. Between this termination and the great south-western escarpment of the chalk, there occur insulated patches of the same tertiary deposits, and many large blocks of puddingstone and of gray-wether sandstone, which show that the original limits of the tertiary formations extended far beyond their present outlines, and were probably almost coextensive with the chalk. Thus near Came Down on the Ridgeway about four miles south of Dorchester, we have a deposit of rounded chalk-flint pebbles, resembling the round tertiary gravel of Blackheath, near Lon-

* Outlines of the Geology of England and Wales, by the Rev. W. D. Conybeare, F.G.S. &c., and William Phillips, F.G.S. &c., pp. 182, 192.

† Geological Transactions, First Series, vol. ii. Plate IX.

‡ Geological Map of England and Wales, by G. B. Greenough, Esq. P. G. S. 1819.

don: and at the summit of Black Down, six miles south-west of Dorchester, which forms the highest hill within our district, we have a considerable series of beds of similar pebbles, sand, brick earth, and plastic clay*, analogous to the outlying fragments of the plastic clay formation which crown many of the highest summits of the downs of Wiltshire and Hampshire, and are described in Dr. Buckland's paper on Valleys of Elevation†.

Upon the high table land of chalk, also, on which this plastic clay of Black Down rests, we have numerous blocks of siliceous pudding-stone, scattered over the surface of the fields, and composed, like that of Hertfordshire, of a congeries of chalk flints imbedded in highly indurated siliceous sand: these blocks also contain occasionally, though rarely, a few angular fragments of chert from the greensand formation, and a few small pebbles of white quartz. The chalk flints which make up the greatest part of their substance are not all rounded, as in the Hertfordshire pudding-stone, but for the most part are angular, as in the case of similar insulated blocks which occur on the hills of greensand near Sidmouth; and this angular condition deserves peculiar notice, as it seems to connect them with the next deposits we are about to mention, some of which may possibly be referred to the era of the plastic clay formation. In two deep and steep combs excavated in chalk on the west and south of Black Down Hill, viz. at Bride Bottom on the west, and at Portisham on the south, these blocks of angular breccia are accumulated as thickly as the gray-wethers in Clatford Bottom, near Kennet, on the Marlborough downs: their abundance in Bride Bottom has caused it to be called the Valley of Stones. This bottom forms the upper extremity of the Vale of Bredy, where it contracts into a deep and narrow comb, at the head of which the blocks are spread over a space of several acres, like a flock of sheep, often so close together that a man may leap successively from one to another of them.

On the south side of the plain of Black Down we have another collection of huge blocks of the same breccia in the steep comb which descends the chalk escarpment into the village of Portisham: they are most abundant in the village itself, where they lie so thick that they partly obstruct the street, and when they occur in the line of the houses the walls are built upon them: their extreme hardness and bulk have hitherto prevented their removal or destruction by the hand of man. In the street at West Lulworth, also, similar

* These strata supply materials to a manufactory of bricks, tiles, and coarse pottery that is established on this hill. The clay exhibits the same varieties of colour, viz. blood-red, yellow, white, and black, which are so characteristic of the plastic clay formation, and are so well shown in Alum Bay and at Reading.

† Geological Transactions, Second Series, vol. ii. Part I., p. 119—130.

blocks of the same stone lie in the line of the front of some cottages, and are built into the walls. In Dr. Kidd's Geological Essay, p. 177, a similar collection of siliceous boulders is described as scattered over a dry valley, high up on the chalk downs of Berkshire, near Ashdown Park, on the south of Swindon, so thickly as to render the road inconvenient, even to a foot traveller. Although these blocks have been entirely separated from the matrix in which they were formed, they are very slightly rolled, and have been drifted but to a small distance from their native place.

We think it right to refer to the action of water, probably in more than one period of the tertiary formations, certain deposits of angular gravel which occur on the summits of many hills within our district. A remarkable example of this kind, composed of an admixture of unrolled chalk flints with yellow clay and sand, is seen in the upper margin of the cliffs at White Nore, where it forms a continuous bed, varying in thickness from two to twenty feet, level at its upper surface, but extremely irregular below, and filling up deep holes and furrows (*puits naturelles*), which pervade the entire surface of the subjacent chalk.

These deposits seem due to the effect of water dissolving the chalky matrix of the flints, but not sufficiently agitated to roll them into pebbles, nor to move them from the spot on which the dissolution of the chalk had taken place. The most instructive example we know of the effects of this dissolving operation is at Dunscombe Hill, on the east of Sidmouth, where, on the summit of a ridge of chalk, of which the surface is furrowed with pits and hollows that are evidently due to the action of water, we find an unstratified mass of chalk flints, which have not undergone the slightest rolling, piled on each other, and intermixed with loose sand and clay; the outer portions of this mass, from which the rain has washed away the sand and clay, lie loose and hollow, like stones in an artificial barrow, or in a wall constructed without mortar. It is scarcely possible to explain the actual state and position of these flints but by supposing that the chalk in which they were formed has been gradually dissolved in a quiet sea. To the same operation of quiet solution we must also refer analogous deposits of angular chalk flints and yellow clay which fill the irregular and deep troughs and hollows that fringe the upper margin of the chalk in the cliffs from Lyme to Axmouth, in a manner similar to that we have described at White Nore.

Cavities and projections of this kind appear to be universal on the surface of the chalk wherever it is covered up with any kind of tertiary strata, and has been protected by them from the levelling effects of atmospheric agents; in all these cases the actual surface of the land affords no indications of the

irregularities which exist below: but however rugged be the subjacent surface of the chalk, its irregularities are all obliterated and filled up with breccias and gravel beds, presenting on their upper surface a smooth and continuous outline, whilst their lower surface is curved and dentated downwards, conformably to the furrowed curvatures, and ridges and pinnacles that fringe the upper surface of the chalk on which they rest; the existence of these pits and cavities shows, that the chalk had not been exposed to the levelling effects of atmospheric agents before the deposition of these breccias and gravel beds.

The water which formed these breccias must have been subject to very irregular currents and agitations; for whilst in many places (such as those last mentioned) the solution has been conducted in perfect tranquillity, in other spots it has been attended or followed by agitations which have reduced the flints to perfect roundness, as in the Hertfordshire pudding-stone and Blackheath gravel; and again, in other cases, there is evidence of an intermediate state of action, where only a partial rounding of the fragments has taken place, as in the partly rounded and partly angular chalk flints which form a thick bed reposing on strata of greensand on the summit of Haldon, on the west of Exeter.

Another variety of angular gravel occurs in many beds of shivered chert of the greensand formation, which seem to have undergone a certain degree of decomposition, causing them entirely to break to pieces and crack into angular fragments, and become converted into strata of loose and shivered gravel, on which no mechanical attrition seems to have been produced by the operation of water, but the fractures have resulted from the splitting to pieces of the beds of chert still resting in their natural position. A remarkable example of this kind may be seen in the cliffs that overhang the new road between Lyme and Charmouth, and also on the summit of Abbotsbury Castle. In the oolite formation also, about two miles west of Bridport, a similar dislocation and splitting of the stone has converted to loose breccia the upper beds of inferior oolite on part of the summit of Chideock Hill. This is the only case we have noticed of such an occurrence in the oolite of the coast of Dorset.

It is not easy to distinguish between these undisturbed beds of shivered chert, and accumulations of the same chert which have been very slightly agitated by water, except in cases where the admixture of miscellaneous fragments of other strata shows that moving water has operated in bringing these fragments to their present position amongst the chert. There is also a difficulty in distinguishing the deposits of angular breccia, both of this chert and of the chalk formation, from deposits of diluvial gravel which have been removed

to a small distance only from their native place. The cliffs at Axmouth and near Sidmouth exhibit deposits of such miscellaneous diluvial gravel, resting on red marl, and adjacent to beds of uniform and angular chalk-flint breccia that rest on the chalk.

These deposits of breccia on the coast of Dorset seem analogous to those which are found in Normandy, reposing on the similarly corroded surfaces of the chalk, and which occur also on the surface of other formations in that part of France, each formation respectively being often covered with a capping of loose angular fragments composed of the hardest materials of the subjacent strata. According to M. de Caumont, a breccia allied to the plastic clay formation, and composed of angular chalk flints imbedded in red clay, occasionally attaining the thickness of 80 and 100 feet, occurs in the valley of the Rille, and various adjacent parts of Normandy*. M. de Caumont speaks of all these breccias under the head of Diluvium,—falling into the same common error with many other Continental geologists, of including under the term Diluvium many pebble beds and breccias which belong to the tertiary, and to older formations.

Chalk.

The lofty escarpment of chalk which bounds our field of observation on the north, forms the margin of the chalk downs of the southern part of Dorsetshire, and is the direct continuation of the south frontier of the great chalk basin of Dorset and Hants. Along great part of this south frontier, from the east extremity of the Isle of Wight to the west extremity of Purbeck, and thence to the cliffs of White Nore, where we enter on its history, Mr. Webster has shown its position to be sometimes absolutely vertical, but for the most part dipping at a very high angle northwards towards the interior of the basin†. This high inclination ceases a little east of the promontory of White Nore, where the chalk suddenly sweeps round, and dips at an angle of a few degrees only to the north-east. Along the range of its escarpment westward, for nearly twenty miles from White Nore to its termination at Chilcomb Hill, on the east of Bridport, the dip is almost constantly towards the north, at angles varying from 10° to 40°. Its mean elevation along all this range may be taken at about 500 feet. The base of this escarpment appears throughout to be

* See sections and description in M. de Caumont's *Essai sur la Topographie Géognostique du Calvados;* and De la Beche on the Geology of the North Coast of France, from Fecamp to St. Vaast, in Geol. Trans. Second Series, vol. i. Part I. p. 73—89.

† See Sir Henry Englefield's History of the Isle of Wight, Plate 50; and the Geological Transactions, First Series, vol. ii. Plate XI.

composed of beds of the greensand formation; but these are rendered invisible in the greater part of the Weymouth district, in consequence of a fault which runs along the escarpment for nearly ten miles, from Poxwell to Abbotsbury, and brings up strata, subjacent to the greensand, into immediate contact with the chalk: this fault we shall hereafter describe.

The promontory of White Nore is the last point in the South-west of England at which the great body of the chalk touches the sea; those insulated portions of this formation which occur in the cliffs between Lyme and Sidmouth being only detached outlying masses, separated, by denudations of many miles in width, from the south-west termination of the great chalk basin of Dorsetshire*.

The mineralogical character and organic remains of the chalk in this district present nothing unusual: the lower strata of the chalk pass into hard chalk, devoid of flints, and interspersed irregularly with green grains of silicate of iron.

Greensand.

The strata of the greensand formation, which at White Nore emerge from beneath the lowest chalk, dip conformably with it to the north-east, and attain a thickness of about 100 feet: their succession in a descending order is:—1. Chalky glauconite, composed of greensand interspersed with calcareous cement. 2. Green, yellow, and brown sand, alternating with irregular calcareous concretions, and with thick beds of chert. 3. Dark argillaceous greensand, with large nodular concretions, equivalent to the sandy concretions called cow-stone, at Lyme Regis: the upper subdivisions of this section also closely resemble some of those exhibited by the greensand formation near Lyme.

We are unable to recognise distinctly in this district, or in any part of the coast west of Weymouth, those regular and extensive threefold subdivisions of fire-stone, gault, and lower greensand, which are so obvious in Hants, Sussex, and Kent; although an approximation to the character of fire-stone may be traced at White Nore, and still more decidedly in Devonshire, in the cliff and quarries of Beer already described by Mr. De la Beche†.

For a considerable distance near White Nore and Osmington the greensand is visible at the base of the chalk escarpments, dipping always conformably to the chalk; but along the great escarpment from Poxwell to Abbotsbury it is seen only in two places, namely, near Sutton Pointz, and at Bincombe, being elsewhere masked by the Portland stone, which the great fault that

* See Map, Plate I.

† Geological Transactions, Second Series, vol. ii. p. 109.

runs along this escarpment brings up into absolute contact with the chalk. At these two places, however, its thickness is so great as to leave little doubt that it continues in its proper place beneath the chalk, to the west extremity of the fault near Abbotsbury, where it is again exposed, and forms a considerable feature in the escarpment of White Hill, overhanging the village of Abbotsbury, and projecting thence nearly two miles westward into the summit of the long and elevated ridge of Abbotsbury Castle. From Abbotsbury Castle it turns northward, still forming the sub-escarpment of the chalk, along the entire east and north frontier of the Vale of Bredy. It appears also on the summit of Swyre Knoll, Hammerdon Hill, and Shipton Beacon, which form three remarkable outlying hills on the flanks of the Vale of Bredy, and in much greater force on the summits of the insulated hills of Golden Cap, Hadden Hill, Stonebarrow Hill, Coneygore, and Conig Castle near Charmouth; and further north, on the lofty tops of Lewsdon Hill, Pillesdon Hill, and Black Down near Broadwindsor*. In the escarpment on the north of Abbotsbury we have a distinct section, displaying ledges of hard coarse limestone, loaded with grains of quartz and silicate of iron, and alternating with thick strata of chert; a little further west, at Abbotsbury Castle, the calcareous matter ceases, and is replaced by strata of chert. These calcareous and cherty strata of the greensand at Abbotsbury, afford an interesting object of comparison with those in the neighbourhood of Lyme Regis, described by Mr. De la Beche†, as well as with those at White Nore. The occasional presence of so much calcareous matter in the greensand, seems to justify the appellation of *craie chloritée*, given by the French to the uppermost strata of the greensand formation.

The greensand in our Weymouth district is found to overlie and repose successively on formations of different ages; thus, in the valley of Upton on the east of Osmington it rests on the Purbeck beds‡; in the south escarpment of Upton Hill towards Ringstead Bay, on Portland stone§; on the west of Osmington Mill, on Kimmeridge clay‖; at Abbotsbury Common, on a clay which is probably the Oxford clay¶; at Golden Cap Hill, on inferior oolite**; near Lyme Regis, upon lias††; and at Axmouth and Beer, upon red marl‡‡. The same overlapping disposition of the greensand has been ob-

* See Map, Plate I.

† Geological Transactions, Second Series, vol. ii. pp. 109, &c.

‡ See Plate II. fig. 2 & 3.

§ See Plate II. fig. 2.

‖ See Plate II. fig. 9.

¶ See Plate II. fig. 6 & 7.

** Geological Transactions, Second Series, vol. i. Part I. Plate VIII. and Plate XIV. No. 1. In these sections the inferior oolite was omitted by mistake, but is inserted in a section of the same coast, in Pl. III. of Mr. De la Beche's Sections and Views Illustrative of Geological Phænomena.

†† Ibid. Plate VIII.

‡‡ Ibid. Plate XIV. No. 2.

served by Mr. De la Beche* and M. de Caumont in Normandy†, where it overlaps successively the formations of Kimmeridge clay, coral rag, and Oxford clay. This circumstance derives an additional importance, at the present time, from the recent paper of M. Elie de Beaumont‡, in which he observes that a connexion exists between the elevation of mountains and succeeding deposits of extensive overlapping strata, e. g. the greensand and chalk in the Jura mountains, filling the longitudinal valleys produced by the elevation of the oolites. On the coast of Dorsetshire no elevation of the strata appears to have taken place between the deposition of the lias and the plastic clay.

Hastings Sand, and Purbeck Beds.

Although the Wealden or Hastings sands do not enter the area of our actual observation, they approach very near to its eastern extremity, becoming gradually thinner in their progress westward through the Isle of Purbeck, until they terminate a little west of Lulworth: this has been already pointed out by Dr. Fitton and Mr. Webster§.

The identity of this Hastings sand with that of Swanwich Bay, at the east extremity of Purbeck, has recently been further confirmed by the Rev. T. O. Bartlett's discovery of the remains of the Iguanodon and other reptiles in the iron sandstone at Swanwich. Bones of this animal have also been recognised by Prof. Buckland and by Mr. Vine in the same sandstone at Sandown Fort, and other places on the south coast of the Isle of Wight.

The Purbeck beds enter our district on the north-west of White Nore, but are seen only in two small insulated patches near the villages of Osmington and Upway. The details of the beds composing the Purbeck series are so fully given by Mr. Webster||, that it is here superfluous for us to say anything respecting them, further than that several of their most remarkable varieties are recognised and wrought even to their final termination on the west of Upway. We trace also throughout this district the remarkable beds of fibrous carbonate of lime that pervade the clay which alternates with the beds of limestone throughout the Isle of Purbeck. The fibres of this limestone, like those of satin spar, are at right angles to the planes of the beds which they compose, and which vary from two to six inches in thickness. From the resemblance of its small and parallel fibres to the fibres of animal muscle, this limestone is known among the workmen by the name of "Beef": it

* Geol. Trans. Second Series, vol. i. Part I. Pl. X.

† *Essai sur le Top. Geog.* Pl. VI.

‡ *Ann. des Sciences Nat.* vol. xvii. Sept. 1829.

§ Annals of Philosophy, 1824, New Series, vol. viii. p. 382: also Sir H. Englefield's History of the Isle of Wight, p. 194.

|| Geological Transactions, Second Series, vol. ii. p. 36.

sometimes entirely occupies the place of the clay between the limestone beds of this formation. One of the most important points in the geological history of the Purbeck series, is the occurrence of a bed of oyster-shells called the "cinder bed," often many feet in thickness, and almost wholly composed of dark-coloured, small oyster-shells in the midst of a series of strata, some of which contain exclusively shells of freshwater formation, and others an admixture of freshwater shells with those which are marine: this circumstance has been duly noticed by Mr. Webster and Dr. Fitton; and although we cannot infer from it the return of the sea for any long period in the middle of the Purbeck formation, yet it shows that the district it occupies could not have been a lake of pure fresh water, but was probably an estuary at the time when these oysters occupied its bottom, and were accumulated to the thickness of many feet over a distance of many miles*.

We are disposed to agree with Mr. Webster, and to adopt more confidently than he has done the opinion he advances with respect to the propriety of referring to the lower region of the Purbeck series the beds of white calcareous slate, usually destitute of organic remains, which occur between the undoubted Purbeck beds and the Portland stone; these beds resemble the compact varieties of Purbeck stone, which are devoid of shells, and which near Lulworth attain a thickness of from 60 to 100 feet. In Portland the

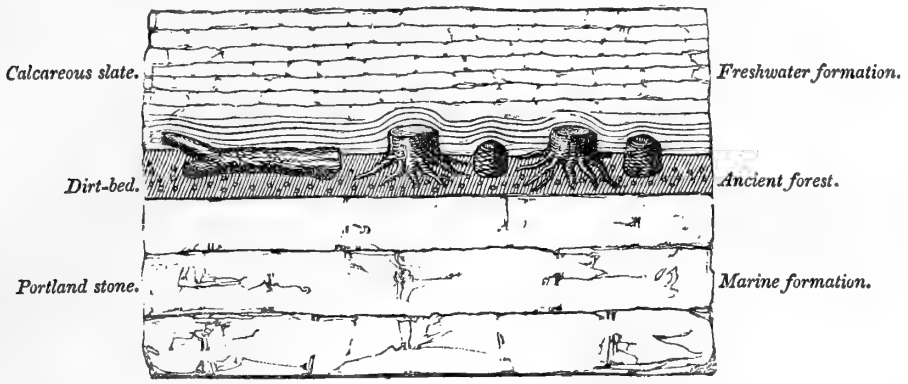
* The following description of the actual state of the lake Menzalé at the mouth of the Nile, by a modern traveller, is highly illustrative of the mode in which living animals of a mixed character are associated together near the confluence of great rivers with the sea.

"The *lake Menzalé* is only five miles distant from Damietta. I should judge it to be sixty-five miles long, and fifteen broad: it is not, properly speaking, a maritime lake, but formed by the increase of the Damietta branch of the Nile; the depth is from three to five feet, and on pushing an oar to the bottom I have observed it coated with the common mud of the Nile for about twenty inches deep. Along all the length of the lake a narrow tongue of land separates it from the sea, but not wholly: there are four passages through which it is possible for barks to sail; through two of them I passed with a good deal of difficulty. At the mouth of each there is a bar of sand, which makes the passage perilous from the sea. No sea or lake in the world can perhaps boast of the same quantity of fish in a given space as the lake of Menzalé.

"The principal sorts of fish caught here are the *Perca Luth*, or Lot's perch; another species called *kescher;* the *charamoot* or *Silurus anguillaris*,—the fin is said to be poisonous; the *burra*, or red mullet; the *kelp el bahr*, or sea-dog; the *casheff*, or *Mormyrus anguilloides* of Linnæus; this I have seen weighing thirty pounds. The salmon of the Nile is found in the upper part of *Menzalé* weighing from 80 to 100 pounds. The mixture of sea and river water in the lake causes it to be neither salt nor sweet; so that both river and sea fish are to be found here in equal quantity: but both, in my opinion, of an inferior quality. The quantity of birds which cover the lake is prodigious. Pelicans, cormorants, cranes, and herons live only on the fish."—*Madden's Travels in Egypt, &c.* vol. ii. p. 171—175.

lowest of them form the surface of the island, and cover the true Portland stone with a deposit of freshwater formation. This formation presents beds of chert containing freshwater shells, near the Ridgeway fault, on the west side of the road from Weymouth to Dorchester; and also beds of chert containing chalcedonic casts of minute freshwater shells, at the water's edge, on the east side of Lulworth Cove.

Section of the Dirt-bed in the Isle of Portland.

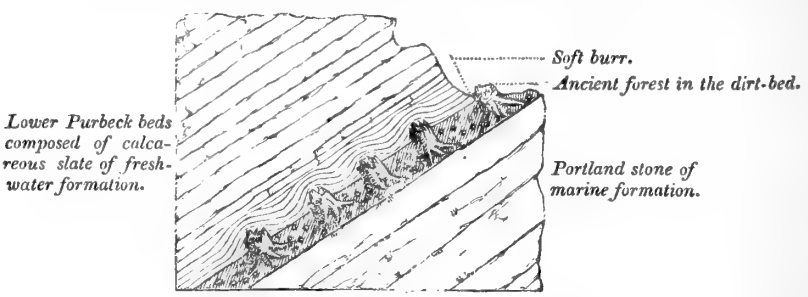


We consider a small stratum, called by the workmen "Dirt-bed," to be by far the most interesting and remarkable deposit in this district. It seems to be made up of black loam, mixed with the exuviæ of tropical plants, accumulated on the spot on which they grew, and preserved during a series of years, in which the surface of the Portland stone had for a time become dry land, and accumulated a soil of about a foot in thickness, composed of an admixture of earth and black vegetable matter, interspersed with slightly rounded fragments of stone, which Mr. Webster ascertained to be from the lower part of the Portland series. These fragments are found to be almost coextensive with the dirt-bed, and the fact that we have yet found with them no admixture of pebbles derived from the subjacent oolites, or from any other more ancient rocks, shows that no violent rush of water from any distant region took place during the period in which these pebbles of Portland stone were under the process of becoming slightly rounded.

This dirt-bed, as Mr. Webster has stated, forms the matrix of the silicified trunks of very large coniferous trees, which are so abundant in the Isle of Portland, and are found there coextensive with the upper surface of the Portland stone. Wherever the dirt-bed is laid open to extract the subjacent building-stone, it is found to contain these silicified trees laid prostrate, partly sunk into the black earth, and partly covered by the superjacent calcareo-siliceous slate: from this slate the silex, to which the trees are now converted, must

have been derived. A bed of snow falling on a modern peat-bog, and covering the upper portion of prostrate trees, whose lower portion has been sunk by their weight into the substance of the peat, would represent the position of the calcareous slate which immediately covers these fossil trees in Portland: some of them extend to a length exceeding thirty feet, and bifurcate at their upper end; but the branches are not continuous to their extremities, and we find no traces of leaves. The leaves and small branches, and exterior parts of the trunks, had probably decayed, whilst they lay exposed to air on the surface of the peat. Amid these prostrate trees, many of which attain three and four feet in diameter, we find silicified stems of plants closely resembling the modern Cycas and Zamia: these have been described by Prof. Buckland under the name of Cycadeoideæ*, and are important, as indicating that the temperature in which they grew was much higher than that of our present climate. We find also, at nearly the same intervals at which trees are found growing in a modern forest, an assemblage of silicified stumps or stools of large trees, with their roots attached to the earth in which they grew. These stumps are from one to three feet long: they are mostly erect, whilst a few are slightly inclined. The black earth which contains their roots seldom exceeds one foot in thickness; the upper portions of the stumps, as represented by Mr. Webster†, project upwards into the substance of the superjacent stone (called "soft Burr" and "Aish"), which gives indication of their presence by hemispherical concretions accumulated around the top of each stump of wood‡.

Section of the Cliff east of Lulworth Cove.



In the highly inclined strata of the cliff, about a furlong east of Lulworth Cove, and represented in the above sketch, we find a considerable number of these silicified stumps, some entirely laid bare by the washing of the sea, others partly exposed and partly covered, and others still wholly encased with

* Geological Transactions, Second Series, vol. ii. Part III. p. 395.

† Ibid. vol. ii. Part I. Pl. 6. fig. 3, 4.

‡ See wood-cut at p. 13.

concretions of soft burr, and all having their roots fixed in the dirt-bed, which occurs here also of the same thickness, and in precisely the same relative place, and interspersed with the same rounded fragments of limestone which it contains in the Isle of Portland: the position of these stumps, at an angle nearly of 45° to the horizon, affords a striking proof of the elevation which the strata have undergone. We find the dirt-bed also on the top of the Portland stone, in the sections of some quarries along the Ridgeway, e. g. near Upway, on the north of Weymouth, and at the western termination of the Portland stone near Portisham, at the distance of twenty miles west from Lulworth. Dr. Buckland has found slight traces of this dirt-bed on the upper surface of a stratum of Portland stone in the quarries about two miles north of Thame, in Oxfordshire: it is here covered by a few feet of clay, in which he found no other animal remains than fragments of some Testudo, too small to point out the genus to which they belong. The recognition of this very remarkable bed in a locality so distant from Portland seems to indicate that it may be found to be nearly coextensive with the Portland formation throughout England; and it well merits the attention of future observers to search for it in the Vale of Aylesbury, and in the two localities of the Portland stone intermediate between Oxford and Dorsetshire, namely, at Swindon and Tisbury. The probability of its occurrence at Tisbury is increased by the recent recognition of the Cycadeoideæ at this place by Miss Benett*. We consider this dirt-bed as quite decisive in forming the barrier between the Portland and Purbeck formations: its deposition must have proceeded during a considerable period of time, antecedently to which the districts it occupies were entirely submerged beneath the sea, and subsequently to which the waters again returned to overwhelm them, first with a deposit of about 1000 feet of the semi-lacustrine sediments of a great estuary (including the united thickness of the Purbeck series and the Wealden sands

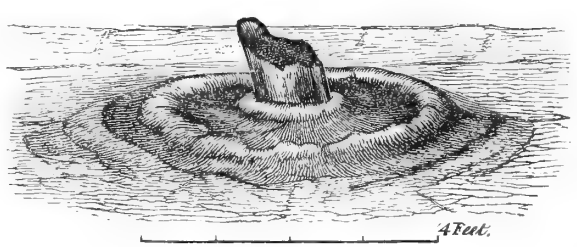
* Dr. Fitton has discovered this deposit on the opposite side of the Channel in the Boulonnois, and has thus described it in the Annals of Philosophy, December, 1826. "Some traces of the lowest members of the group to which these two strata (Weald clay and Hastings sand) belong, and which is remarkable from its containing throughout the remains of freshwater shells, are visible on the summit of the cliffs between Gris-nez and Equinen, where a thin bed occurs of somewhat bituminous clay, abounding in silicified wood, the cavities of which are coated with minute crystals of quartz. This bed corresponds precisely to that which exists on the top of the Isle of Portland, bearing there the name of 'Dirt,' and abounding in similar wood; and on the French coast it is associated with beds of limestone, different from the stone beneath, and containing shells in great numbers, apparently of the genera Cyclas and Ampullaria." Dr. Fitton has also recognised thin fissile beds of Purbeck stone containing freshwater shells, e. g. Cyclas and Cypris, at Whitchurch in Bucks.

and clays), and afterwards with a series of marine deposits amounting to much more than 1000 feet of greensand and chalk.

Throughout the entire succession of all these changes there is no evidence of any sudden and violent disturbance causing either elevation or depression of the Portland stone, or of the subjacent oolites. The present high inclination of all these beds is uniformly parallel to that of the beds of Purbeck stone, greensand, and chalk; and these all seem to have been raised simultaneously by the same convulsion which elevated the axis of the Weymouth district, together with all the inclined strata in Purbeck and the Isle of Wight.

We have a measure of the duration of the period during which the surface of the Portland stone continued in the state of dry land, covered with forest, in the thickness of the "Dirt Bed," which has accumulated more than a foot of black earth, loaded with the wreck of its vegetation. The regular and uniform preservation of this thin bed of black earth over a distance of so many miles, shows that the change from dry land to the state of a freshwater lake or estuary was not accompanied by any violent denudation or rush of water, since the loose black earth, together with the trees which lay prostrate on its surface, must inevitably have been swept away had any such violent catastrophe then taken place*.

* Prof. Henslow in the summer of 1832 found in the top cap of the Portland stone, immediately beneath the dirt-bed, root-shaped cavities descending from the bottom of the dirt-bed into the subjacent solid stone; this top cap should seem, therefore, to have been occupied by the roots of the trees which grew in the dirt-bed, and penetrated the Portland stone whilst it was yet soft and unconsolidated. He also noticed in Portland two partial and very thin seams of black earth; the uppermost at the distance of five feet, and the lowermost of seven feet, below the dirt-bed: these seams of black earth are important, as they mark two short intervals during which vegetable matter had begun to accumulate on the surface of the soft and gradually increasing materials of the uppermost beds of the Portland stone, whilst they were just rising above the level of the sea. The incipient bed of vegetable matter was thus twice interrupted in its progress, and buried beneath an influx, first of two feet, and next of five feet, of earthy sediment, before the general surface on which the true dirt-bed rests had been raised entirely above the water.



The above cut represents an example which in the summer of 1832 occurred to Prof. Henslow in the Isle of Portland, in a quarry where the surface of the burr had been laid bare,

Portland Stone.

As the details of the component beds and fossils of the Portland series have been sufficiently described by Mr. Webster and Mr. Conybeare, we shall

of an erect stump protruding through the burr stone into the superior stratum called Aish, analogous to that represented by Mr. Webster in his section of the Portland beds (Geol. Trans. Second Series, vol. ii. p. 1. Plate VI. fig. 3 and 4.), and which the workmen stated to be of rare occurrence; this superior stratum exhibited to Prof. Henslow two or three of those conical and dome-shaped protuberances which so generally indicate the presence of stumps of trees immediately beneath them. In the case represented, the protruding stump being longer than the rest, the burr stone was not deposited in sufficient thickness to cover it, but was heaped around it in two circular ridges, with intermediate circular depressions. From these appearances we may infer that a state of great tranquillity attended the deposition of the calcareous sediment of which the dome-shaped caps that cover the shorter stumps were formed (See Section of the Dirt-bed, page 13.) The circular ridges and depressions which surround the taller stumps (see page 16,) seem to have been produced by an interruption of the undulations on the surface of water so shallow that the waves were caught and broken by a stump but four feet high, whilst they passed over the shorter stools immediately adjacent to them; these interrupted undulations being propagated first downwards and then outwards along and around the stump whose top was high enough to obstruct the ripple on the surface of the shallow lake, by which the dirt-bed was gradually inundated.

Here, then, we have proofs of a tranquil state and gentle action of water in the period immediately succeeding, as well as in that which preceded, the formation of the dirt-bed, upon a surface that became dry land during a short time intermediate between the transition of the district which it covers from a submarine state to that of a freshwater lake. The rapid possession which in our modern tropics is taken by the Pandanus or Screw Pine and Cocoa-nut Palm of the first banks and reefs of coral islands that emerge above the level of the sea, affords an example of the luxuriant growth of vegetables on the margin of land just rising above the water, analogous to the ancient juxtamarine forest the remains of which contributed to the formation of the dirt-bed, in the region which has now become the southern coast of Dorsetshire.

With respect to the silicified trees Prof. Henslow makes the following observations:—

"From what I saw I should think that all the erect stumps must have suffered considerable decay before they had become imbedded, or at least fossilized, in the burr. They consisted of no more than the central portion of the wood just above and below the neck of the trees, which had every appearance of having grown in the places which they still occupy.

"In a quarry of very white and chalk-like Portland stone, at the base of Chalbury Hill, near Preston, I found a cylindrical mass of flint ten inches in diameter, reposing upon a soot-like mass of carbonaceous matter, probably resulting from the decomposition of leaves and bark, and forming an envelope to the lower part of the cylinder, but not extending beyond it. Upon cracking off as much of this cylinder as protruded from the side of the quarry, I perceived the central portions, of three inches in diameter, to consist of fossilized wood. It appears to me most probable that the whole cylinder had occupied the space originally filled by the trunk or branch of a tree; but that during the process of its becoming silicified, the organic structure of the outer portions had not been impressed upon the flint. In the Isle of Portland the quarry-men collect a similar black vegetable substance, which they use for blacking."

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only refer to their account of them*, and to our own detailed section of Black Nore on the west cliff of the Isle of Portland†. We have little to add to what these authors have published, except the occurrence of bones of Saurians which we discovered in the cliff of Black Nore, imbedded in compact Portland stone.

We have stated in our introduction that this district contains two distinct ranges of Portland stone; one constituting the table-land of the Isle of Portland, dipping southwards beneath the sea, and rising with an elevated escarpment northwards towards the bay and valley of Weymouth; the other constituting a long and narrow line of elevated hills, parallel, and immediately subjacent, to the chalk escarpment of the Ridgeway, and presenting a continuous and lofty escarpment towards the south. In fact, these hills occupy the position which in districts that have been less disturbed is usually held by the sub-escarpments of the greensand formation, where it emerges regularly from beneath the chalk: such are the escarpments of greensand which in Kent and Sussex extend from Folkstone, by Coxheath, Nutfield, and Leith Hill, to Godalming. A glance at our map will show that along the northern frontier of the Vale of Weymouth this ridge of Portland stone forms a continuous band from the east extremity of our district near White Nore to Portisham, where it suddenly terminates in the great fault, and is found nowhere further west in England. Along nearly the whole of this tract it attains a high elevation, rising near the central part at least 500 feet into the lofty eminences of Preston Hill, Charlbury, and Bincombe Hill: at these three places its elevation is little less than that of the chalk itself. On the west of Upway it forms a narrow ridge or hog's back from Upway to Portisham, known by the name of Corton Hill and Waddon, dipping at an angle of about 45° to the north. Although these Portland beds dip thus rapidly to the north, through great part of the range now under consideration, yet such is the dislocation and elevation they have suffered along the line of the great fault, that their northern margin is seldom brought into contact with any other strata than the chalk. On the west of Upway this line of contact is marked by a longitudinal valley, flanked on its north side by the chalk escarpment, and on its south side by the upper Portland strata of Corton Hill‡: thus, the Portland beds dipping to the north in Corton Hill, and south along the fault, form a trough in which reposes a long and narrow strip of Purbeck strata, extending more than a mile both on the east and west of Upway, and dipping conformably to the double dip of the subjacent Portland

* Geological Transactions, Second Series, vol. ii. p. 37, &c. Outlines of the Geology of England and Wales, p. 172. † Plate III. fig. 3. ‡ See Map, Plate I.

stone. The sudden and total disappearance and termination of the Portland formation at Portisham, seems not to result from its accidental intersection at that place by the great Ridgeway fault; but rather from the tendency which is common to this, with most other great formations, to terminate abruptly where they are accumulated to their fullest thickness; thus we find the full thickness of the chalk and oolite formations exhibited for many hundred miles along the line of their great escarpments throughout England, and in like manner the full Portland strata terminate abruptly in the Vale of Weymouth: they reappear and again terminate with equal abruptness in the Vale of Tisbury, and exhibit nearly the same features of sudden termination in the hills near Brill and Thame in Oxfordshire, and near Aylesbury and Whitchurch in Bucks.

The fact of the interrupted deposition of the Portland formation in England, occurring as it does only in the limited districts just mentioned, and in one other small spot at Swindon, is analogous to the interrupted deposits of other strata, particularly the most recent members of the oolite formation. We know not the cause of these irregularities; the fact may be illustrated by the case of the Kimmeridge clay, which attains at Kimmeridge a thickness of 600 feet, is reduced to 70 feet near Oxford, disappears entirely in some places along its line of bearing, and again resumes its strength in the Vale of Pickering, and near the coast of Yorkshire. The Portland stone has not yet been identified on the opposite coast of Normandy, but M. E'lie de Beaumont states that he has discovered it in Burgundy*, and M. Dufrénoy says that it occurs largely in the vicinity of Angoulesme†. We think it probable that it will soon be recognised among the great calcareous formations of the Alps and Apennines.

Portland Sand‡.

The consolidated and calcareous beds of the Portland stone are separated from the Kimmeridge clay by the interposition of a deposit of sand and marly sandstone at least eighty feet thick, exceeding the total thickness of the Portland stone itself. This deposit is coextensive with the Portland stone throughout nearly the whole of the coast of Dorset, and is well exhibited by a vertical section near Black Nore, on the west cliff of the Isle of Portland, and along the west shore from Black Nore to the village of Chesilton. Its prevailing character is a siliceous sand, so abundantly mixed with grains of green earth, as to be scarcely distinguishable from the lower strata of the greensand formation near Lyme and Seaton: it also contains large semicalcareous

* *Ann. des Sciences Nat.*, July 1829.

† *Annales des Mines*, 1829, vol. ii. p. 434.

‡ See Pl. III. fig. 1. *n. o.* and fig. 3.

concretions resembling the cow-stones in the lower greensand at these two places; its fossils, however, are different, and more allied to those of the oolite; and its position beneath the Portland stone is decisive in separating it totally from the greensand formation. We have adopted for this stratum the name of Portland Sand, being that suggested by Dr. Fitton, who had ascertained its relation in the Boulonnais and in Buckinghamshire*.

This Portland sand is of sufficient importance to be marked on our map by a distinct colour along nearly the whole extent of the base of all the escarpments of Portland stone; its mineralogical resemblance to the greensand of Lyme may be best seen at Corton, about two miles west of Upway, where nearly one half of its substance is made up of grains of green earth.

The following list of fossils from the Portland sand has been prepared by Mr. James Sowerby, from specimens we collected at Black Nore and Chesilton, in the Isle of Portland, and at Corton.

Black Nore.

Serpula plexus, M. C. 598. f. 1.
Mya? (Pullastra of Phillips), only a cast.
Trigonia clavellata, M. C. 87.
Plicatula, a new species, occurs at Weymouth.
Pecten, with concentric laminæ.
Exogyra (*Gryphæa*) *nana*, M. C. 383. f. 3.
Ammonites triplex. M. C. 292, 293.

Chesilton.

Mya? same as at Black Nore.
Venus, only a cast.
Ostrea Hemicyclus, new species.
Exogyra nana.
Ammonites giganteus? young, M. C. 126.

Corton.

Lucina? a fragment.
Cardium, small fragment.
Avicula concentrica, new species, very abundant.
Pinna viminea, new species; found also at Down Cliff, Bridport, in inferior oolite.
Pecten, with concentric laminæ.
Plagiostoma rusticum? M. C. 381.
Ostrea, new?
Anomia? one valve imperfect.
Belemnites, fragment.
Ammonites giganteus? Young, or possibly *A. Vernoni* of Phillips: it is much crushed.
Echinus spines.

The prevailing character of this stratum, along the whole line coloured on the north side of our map, is a bed of siliceous sand and green earth. It is also sandy and full of green earth at the village of Chesil; but at the base of the high west cliff of Portland, under the promontory of Black Nore, where it attains a thickness of eighty feet†, it is mixed with marl, and exhibits subordinate concretions, and beds of sandy marl and sandstone, both containing the same fossils that are found at Chesilton and Corton. Its lowest beds become more argillaceous as they approach nearer to the subjacent Kim-

* See Phil. Mag. and Ann., May 1827, vol. i. p. 139.

† See Pl. III. fig. 1 & 3.

meridge clay; it seems to form a connecting link between the Portland stone and Kimmeridge clay; and, as has been observed by Mr. Conybeare*, is probably identical with the beds of sand and green earth, full of large boulder-shaped semi-calcareous concretions, that occur in Shotover Hill, near Oxford, between Kimmeridge clay and the imperfect upper calcareous Portland beds, which extend from Shotover to Brill and Thame and Aylesbury, and which also are occasionally much loaded with grains of green earth. Dr. Fitton has recognised this sand beneath the calcareous Portland beds at Whitchurch in Bucks: it occurs also in the same position in the Quainton Hills; and Mr. Lonsdale considers the sand which forms the escarpment close on the north and west of the town of Swindon to be also identical with this Portland sand; the calcareous or upper Portland beds occur also beneath and a little to the east of that town. In the Boulonnois, Dr. Fitton describes this formation as consisting of calcareous concretions of great size, as in Oxfordshire and Bucks, abounding in petrifactions, and imbedded in yellowish somewhat ferruginous sand; between Gris-nez and Audreselles the shore is covered with these enormous masses fallen from the sand†.

Kimmeridge Clay.

The general character and fossils of this formation have been already described by Conybeare and Phillips. It is chiefly composed of beds of slaty bituminous clay, interspersed with Septaria and beds of bituminous marlstone. Near its middle region, in Ringstead Bay, it contains thin beds of marly sandstone, full of well preserved organic remains, and through its whole extent it is loaded with deltoid oysters, which are well known to be its most characteristic shell in England; it contains also the *Gryphæa Virgula*, which is considered characteristic of this formation in France, and abounds in it at Shotover near Oxford.

Mr. James Sowerby has prepared the following list of fossils from this marly sandstone in Ringstead Bay.

A carinated Serpula.
Mya depressa, M. C. 418.
Pholadomya, near *Ph. obtusa*.
Venus?
Cardium?
Trigonia elongata, M. C. 431.
Modiola bipartita, M. C. 210. f. 3, 4.
———, a small boring species.
Pinna granulata? a small fragment, M. C. 347.
Ostrea deltoidea, M. C. 148.
Terebratula inconstans, M. C. 277. f. 3, 4.
Pleurotomaria reticulata (Trochus), M. C. 272. f. 2.
Ammonites, species between *A. decipiens* and *A. mutabilis*.
Ammonites rotundus, M. C. 293. f. 3.

* Outlines of the Geology of England and Wales, pp. 166, 173, &c.
† Philosophical Magazine, 1827, New Series, vol. i. p. 139.

On the opposite side of the Channel the Kimmeridge clay occupies the cliffs of Havre and Honfleur, where it lies next beneath the greensand, and it has been further identified by M. Elie de Beaumont, and by M. de Dufrénoy in the South of France. This formation exhibits its best sections and highest elevation near the east extremity of our district in the cliffs of Ringstead Bay and Osmington, where it attains a thickness of about 300 feet.

From Osmington Cliff it continues westward, without interruption, through Preston and Upway Street to Abbotsbury, forming the narrow north belt of clay which we have named from the village of Upway Street. Great part of this belt is marked by a valley parallel and subjacent to the ridge of Portland stone above described, and dividing it from the ridge of Oxford oolite which forms its southern frontier: this belt of clay terminates suddenly about one mile west of Abbotsbury. In the Vale of Bredy, the covered state of the country renders it almost impossible to distinguish the Kimmeridge clay among the different clay beds that occupy a large part of its surface; but we have identified it at Litton Cheney, immediately on the south of that village, containing the *Gryphæa Virgula*.

The southern belt of Kimmeridge clay near Weymouth, occupies a very small portion of the surface, constituting a triangular area, the base of which extends about a mile from Sandsfoot Castle westward, to the Chesil Bank, whilst its apex is at Portland Ferry: but although so small a portion of this belt of clay is here visible on the surface, we have evidence of its submarine continuation from hence to Portland Island, in the clay bottom of the excellent anchorage of Portland Road, beyond which also it appears above the level of the sea in the base of the escarpment at the north extremity of the Isle of Portland, and along its west shore also immediately south of the village of Chesilton. Hence it is clear that the Kimmeridge clay forms the fundamental stratum of the whole island, separated, as we have shown, from the Portland stone by the Portland sand and sandstone last described. The rapid dip of all these strata towards the south, causes the Kimmeridge formations to sink below the level of the sea in the southern portion of the island; whilst that part of its western coast, whose base is composed of these perishable sands and clays, is defended from the tremendous south-western waves by a natural breakwater of enormous masses of Portland stone that have fallen from the summit, and form a barrier against any further encroachments*.

At a point near Portland Ferry, extending over many yards of the shore, Dr. Buckland remembers to have seen, several years ago, a portion of Kim-

* See Plate III. fig. 3.

meridge clay, which is now covered up with sand, and which at that time presented the appearance of slate burnt to the condition of red tiles; we have now strong reason to presume that such combustion may have taken place, since we have at this moment before our eyes the pseudovolcanic phenomena that are exhibiting themselves in the same stratum of Kimmeridge clay near the east extremity of Ringstead Bay, at Holworth Cliff, adjacent to the promontory of White Nore. This pseudovolcanic combustion began in September 1826, and during a period of many months emitted considerable volumes of flame, probably originating in the heat produced by the decomposition of the iron pyrites with which this shale occasionally abounds; in the same manner as in the year 1755, a spontaneous combustion arose and continued during several years in the bituminous shale-beds of the lias in the cliffs at Charmouth;—we have a description of this circumstance in the Chemical Essays of Bishop Watson: it is probable that in each case rain-water acting on iron pyrites has set fire to the bituminous shale; thus ignited, it has gone on burning at Holworth unto the present hour, and may still continue smouldering for a long series of years, the bitumen being here so abundant in some strata of the shale, that it is burnt as fuel in the adjoining cottages; the same bituminous shale is used as fuel in the village of Kimmeridge, and is there called Kimmeridge coal.

This pseudovolcano at Holworth commenced in the face of the cliffs about twenty feet above the sea; its combustion was proceeding feebly when we saw it in September 1829, and it emitted no flame; there was no appearance of any crater, nor has there ever been any kind of explosion. The extent of the surface of clay which has been burnt does not exceed fifty feet square. Within this space are many small fumaroles that exhale bituminous and sulphureous vapours, and some of which are lined with a thin sublimation of sulphur; much of the shale near the central parts has undergone a perfect fusion, and is converted to a cellular slag. In the parts adjacent to this ignited portion of the cliff, where the effect of fire has been less intense, the shale is simply baked and reduced to the condition of red tiles, like that on the shore near Portland Ferry. Should a similar ignition ever take place in the cliffs at Kimmeridge, which are so much more abundantly impregnated with bitumen, the fire may be propagated there for centuries, until the whole of the bitumen is consumed.

Coralline or Oxford Oolite, and Calcareous Grit.

The general thickness of this formation near Weymouth is about 150 feet. It contains beds of oolitic limestone resembling the oolite of Heddington,

Calne, and Scarborough, and in the sandy beds of its lower region, the same huge semi-calcareous concretions that occur in the calcareous grit of Wilts and Oxon. The corals which abound in this formation, in the two last-named counties, and which there give it the name of Coral Rag, are rare on the coast of Dorsetshire, just as reefs of modern corals occur at unconnected intervals in our modern tropical seas. In the Annals of Philosophy* Prof. Sedgwick has published a list of the beds composing the cliffs between Portland Ferry and Weymouth Harbour, and of the principal organic remains which they contain: he divides the whole series into nine groups, which, in the following section, we have subdivided further into thirty-one beds, included between the Kimmeridge clay at the top, and the Oxford clay at the bottom, of the whole series.

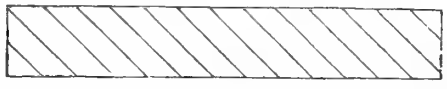
Section between Portland Ferry and Weymouth.—(Order descending.)

1. Considerable thickness of Kimmeridge clay, containing an abundance of the *Ostrea deltoidea*. At about fifteen feet above No. 2, clay iron-stone two feet thick—partly in nodules.
2. Brownish red bed, about six feet—limestone with small vesicles at top, gritty at bottom—cylindrical and round concretions of iron—contains deltoid oysters, Serpulæ, Pectines, Belemnites, and lignite.
3. Grey grit, full of concretions resembling the stalks of Alcyonia, and crossing one another horizontally like a mass of entangled and inosculating roots; the exposed surface is ferruginous.
4. Grey marl-clay.
5. Ferruginous bed, with eagle-stones: at first about one foot thick, afterwards swells out considerably under Sandsfoot Castle. *Lima rudis*? abundant.
6. Sandy grey and green marl—contains a continuous bed of deltoid oysters—also lignite.
7. Grit bed,—brown grey, Alcyonium-shaped concretions—Trigoniæ abundant—one foot. Clay parting.
8. Grit bed,—Trigoniæ abundant; clay parting.
9. Grit bed,—Trigoniæ and *Melania Heddingtoniensis* abundant.
10. Grit bed,—Trigoniæ abundant: the Trigoniæ fill more than half of the beds Nos. 7, 8, 9, & 10.
11. Grey marl.
12. More compact grit—few shells.
13. Same as No. 10.
14. Grit.
15. Grit, with Melaniæ.
16. Grey marl, about four feet.
17. Sandy bed.
18. Limestone full of broken shells.
19. Grit.
20. Dark grey sandy clay, four or five feet.
21. Light brown oolite,—jointed Ammonite—joints filled by hornstone. *Amm. vertebralis*?
22. Grey marl, five feet.
23. Oolite, three feet—marl parting.
24. Oolite, one foot.
25. Gritty marlstone.
26. Grey marlstone and marl, tending to concretions, twenty-five feet.
27. Fox-coloured sands, twelve feet.
28. Grey marl, twenty feet.
29. Alternations of calcareous grit and marls, eighteen feet;—Pectines, oysters, Nautili, Trigoniæ, Serpulæ.

* Annals of Philosophy, May 1826, p. 346.

30. Oolitic grit,—Trochus, Pecten—three beds alternating with marl.
31. Brown, reddish grit—oysters abundant,—Pectines, Ammonites, *Gryphæa dilatata*, *G. bullata*? Trigoniæ.
32. Yellow brown sandy grit, forty feet,—*Gryphæa dilatata*, oysters, sharp-keeled Ammonite, other Ammonites, Pectines, Nautili: the hard beds contain concretions resembling a mass of entangled stems of Alcyonia. Prof. Sedgwick has shown the resemblance of these beds to those of the same formation near Filey Bridge and Scarborough Castle, where the sandstone is similarly aggregated into irregularly branching cylindrical concretions.
33. Oxford clay, abounding in *Gryphæa dilatata*.

It appears from this section, that the Oxford oolite formation is composed of alternations of imperfectly oolitic limestone and calcareous grit, with numerous partings of clay. The superior beds are loose and sandy, and may be considered analogous to the upper calcareous grit in Yorkshire, described by Mr. Phillips; they are best seen near Sandsfoot Castle, where the uppermost of them contain deltoid oysters, and become gradually more argillaceous until they pass into Kimmeridge clay: the central beds are the most oolitic, sometimes loose and sandy, and at other times compact and in continuous beds: they are most oolitic at the village of Wyke Regis and in the cliffs near Osmington, at both which places they afford a light-coloured building-stone, which, but for the vicinity of Portland, might have been applied to purposes of architecture. In the cliffs west of Wyke Regis, they show the same oblique cleavage which is so common in oolitic strata. Thus M. Boblaye, in his paper on the Jura Formation in the North of France*, notices that in the great oolitic quarries of Ballon near Stenay, lines of false division cross the true stratification at angles of 45° or 50°. Examples of the same kind are seen in the Oxford oolite quarries at Heddington, and in the forest marble and great oolite along the road from Cirencester to Bath; similar partings occur also in the new red sandstone at Bridgenorth, but in a manner much more complicated, and crossing the true strata in all possible directions.



Beneath these central oolitic beds, strata of semi-calcareous sand and calcareous grit prevail, and display alternations of sand and sandy loam, with continuous beds of calcareous grit and beds of large concretions lodged in strata of sand. The entire thickness of these calcareous grit beds with their largest concretions, is best exhibited in Ham Cliff, about three miles north-east of Weymouth†. In the hill immediately on the west of Weymouth, the

* *Ann. des Scien. Nat.*, Mai 1829.

† See Plate II. fig. 8.

sandy loam beds of this formation afford an useful brick earth. The passage of the lowest strata into Oxford clay is indicated by the presence of the *Gryphæa dilatata* in the beds of grit, and this passage is analogous to that which occurs at Heddington Hill near Oxford; but the presence of an upper calcareous grit and gradual passage of the superior strata at Weymouth into Kimmeridge clay, show a more perfect development of this part of the oolite formation in Dorset than in Oxfordshire. In the sections at Heddington the upper grit is wanting, and the Kimmeridge clay reposes immediately on the oolitic building-stone: the surface of this stone is also guttered over and furrowed with water-worn cavities and small rock-basins, marking a destructive action of the sea before the deposition of the Kimmeridge clay: this water-worn surface of the oolite is also decomposed and become rusty to the depth of about a foot, in a manner unusual where the series of depositions has been regularly continuous, and its decomposition seems to have resulted from long exposure to water before the laying on of the Kimmeridge clay. These circumstances are duly noticed by Conybeare and Phillips*.

All the beds of the Oxford oolite formation near Weymouth are loaded with shells similar to those found in the same formation in Wiltshire, Oxford-

* Outlines of the Geology of England and Wales, p. 189, note.

Prof. Sedgwick, in his comparison of the appearance of the coral rag formation near Scarborough and Weymouth with that of Oxford (Ann. of Phil., May 1826), conjectures that the upper portions of the Scarborough and Weymouth sections may be wanting near Oxford, and that the coral rag and freestone of Heddington together, represent the central group of the Weymouth and Steeple Ashton sections: thus, at its two extremities in the coast of Dorset and Yorkshire, the superior members of this formation are most fully developed, whilst they are wanting, and have been apparently removed from the central part of their range near Oxford. We entirely agree with Prof. Sedgwick in these remarks, and in the consequences which he draws as to the imperfection of the type of this formation near Oxford: the whole of this subject has been fully illustrated by Mr. Phillips in his excellent work on the Coast of Yorkshire, and still more recently by Mr. Lonsdale in his valuable paper on the Oolite District near Bath (Geol. Trans. vol. iii. Part II. p. 262), in which he gives a section of the Oxford oolite formation at Highworth, where the upper members are represented by about seven feet of alternating beds of sand and rubbly oolite, or oolitic calcareous grit: he also shows that near Steeple Ashton the superior beds appear under the form of ten feet of sand, resting on ten feet of ferruginous clay interspersed with oolitic grains of hydrate of iron. Some bones of a Plesiosaurus have been found in this clay by Mr. Mead.

According to M. de Caumont, a similar alternation of strata of sand and calcareous sandstone, with beds of clay and of imperfect oolitic limestone, affords, on the coast of Normandy, a group corresponding with the upper calcareous grits of Weymouth and the coast of Yorkshire, interposed between the Kimmeridge clay and the coral rag. (See M. de Caumont's Sectional Lists of the Cliff at Hennequeville; of the Hill of Glos near Lisieux; and of St. Julien-sur-Calone near Pont l'Evêque. pp. 113, 114, 115.)

shire, and Yorkshire. The *Trigonia clavellata* and *Melania Heddingtoniensis* are among the most abundant.

Another feature which is wanting in Oxfordshire, is the highly ferruginous character which this oolitic formation assumes near Weymouth, particularly in its upper beds immediately below the Kimmeridge clay; the same ferruginous character prevails also in other parts of its course through this district, and very remarkably in the hills near Abbotsbury. In a ravine called the Red Lane, immediately north of that village, the oolitic grains are composed of a rich hydrate of iron, which, if the country afforded fuel, might be wrought as an ore of the same quality with that which supplies so many iron-foundries in France, from a similar granular ore in the oolite formation.

The extent of surface occupied by the Oxford oolite and its subordinate grits in the valley of Weymouth, will best be seen on the Map; it forms two parallel belts of unequal breadth and length, subjacent to the two beds of Kimmeridge clay before described, and reposing on two other parallel belts of Oxford clay; these oolitic belts terminate in two ridges, overhanging the Oxford clay, with two escarpments that face towards each other; the most southerly of them extends nearly two miles west, from the town of Weymouth to the Fleet at Linch, and is about one mile broad; the northern ridge and its escarpment occupies a length of twelve miles, from the cliffs of Osmington to the sea at Abbotsbury, terminating in an escarpment towards the south, which presents its highest inland elevation in Linton Hill near Abbotsbury. In no part of its course does it much exceed half a mile in breadth, excepting at its western termination near Abbotsbury, where it widens to about a mile, from the effect of the great fault hereafter to be described; here also it changes its dip from north, first to east, and then to south, bending round and enlarging itself like the bowl of a spoon, whose handle is represented by the long ridge of Linton Hill, just mentioned. The towers of St. Catherine's Chapel at Abbotsbury, and of Wyke Regis Church, are two remarkable landmarks, placed respectively near the western termination of the northern and southern belts of oolite just described, and serve as points by which their course may be recognised from the Dorchester road and hills adjacent to it near Weymouth. In the Vale of Bredy, the oolite occurs only in a very narrow band, extending about a mile from east to west, from Kingston House to the village of Litton Cheney; it is seen only in a few old quarries near these two places, and in a hollow way at Litton Cheney, where it appears much disturbed by a fault, and brought, as at Abbotsbury, almost into close contact with the base of the escarpment of the chalk.

Oxford Clay.

The Oxford clay in this district attains a thickness of about 300 feet, and reposes immediately, and with conformable dip, on the central arch of cornbrash and forest marble; on the south side of this arch it forms a belt of low ground about a mile broad, extending from Melcombe Regis and Weymouth Bay to East Fleet. It winds round the eastern extremity of the forest marble at the Barracks, and the marsh of Lodmoor, and thence extends westward along the north side of the central arch, forming a valley of less than half a mile in width, to the Decoy and Swanery at Abbotsbury, where it terminates in the Chesil Bank. Its eastern termination is seen in the lowest strata at the base of Jordon Hill and Ham Cliff, about three miles north-east of Weymouth*.

A distinct section of this stratum occurs in a low cliff under the Barracks at Radipole, where it dips south at about 20°, and where, till lately, it presented, at low water, a pavement of large and beautiful Septaria, known provincially by the name of Turtle Stones. The veins of these Septaria are filled with yellow semi-transparent calcareous spar, often passing into a rich deep brown colour: their beauty, when polished, has, within these few years, caused the greater part of them to be taken up and manufactured into slabs and tables.

In this same section at Radipole Barracks large Ammonites and other shells abound. The most characteristic shell is the *Gryphæa dilatata*, which is as universally abundant in the Oxford clay throughout this district, as the deltoid oyster is in the Kimmeridge clay. In consequence of the want of sections, we have not attempted to trace the minute details of this clay in its windings through the Vale of Bredy, in which it forms a marginal band round the eastern and northern frontier of the forest marble. On the opposite coast of Normandy this same Oxford clay occurs at Vaches Noires, and abounds with the *Gryphæa dilatata*, and many other fossil shells.

Forest Marble.

The formations, which, for convenience of description we have united under the name of Forest marble, and which are the lowest that occur in the Vale of Weymouth, admit of a three-fold division;—1. Cornbrash; 2. Forest marble; 3. Clay, and marlstone.

1. The uppermost region, or cornbrash, is composed of a loose rubbly limestone, alternating with thin beds of clay and marl, and is so absolutely

* See Plate II. fig. 8.

identical, both in its mineral characters and abundant organic remains, with the cornbrash of Wiltshire, that no further description need be given of it than may be found in Conybeare and Phillips's account of Cornbrash*.

2. The middle region, consisting of the usual well-known varieties of forest marble, sometimes constituting thick beds of stone composed of comminuted shells, at other times passing into oolitic and sandy slate. The most perfect condition of this forest marble is exhibited in the quarries of Bothenhampton, one mile south of Bridport, where it contains that remarkable fossil the Bradford Encrinite, *Apiocrinites rotundus*, together with fragments of Pentacrinite, palates of fish, and fragments of lignite, all imbedded in indurated masses of broken shells; it contains also the same Apiocrinite in the under-cliff between Abbotsbury Castle and the sea, and in the cliffs immediately west of Bridport Harbour.

3. The lower region is composed principally of strata of blue clay and grey marl and marlstone, containing subordinate beds of imperfect stone.

The best section of this grey marl is seen in the cliff at Watton Hill, close on the west of Bridport Harbour, attaining a thickness of about 150 feet; it is here capped by an outlying summit of forest marble, being the extreme south-western termination of this rock on the coast of England†. The base of this marl reposes on the sands of the inferior oolite. This grey marl also forms a cap on the summit of the inferior oolite in Burton Cliff, on the east of Bridport Harbour: it may probably be the equivalent of the Fuller's earth in the vicinity of Bath. The predominating character of these three deposits, which we have grouped together as forest marble, is clay; the amount of their united thickness may be about 400 feet.

The extent of this forest marble formation in the Vale of Weymouth is considerable; it occupies a tract near six miles long, and from two to three miles broad, constituting the lowest strata and central belt of that district. This central belt emerges at Radipole from beneath the Oxford clay, and is less elevated than the parallel belts of Oxford oolite and Portland stone, whose escarpments overhang it on the north and south, rising towards each other as if they once had been continuous, and had been separated by the elevation of the central axis of forest marble, over which, if reunited, they would form a continuous ridge. It is not of sufficient importance to trace separately the extent of the individual beds of cornbrash and forest marble throughout this central belt. The cornbrash occupies the uppermost place along the lines of its junction with the Oxford clay, and occurs also on many summits and minor

* Outlines of the Geology of England, p. 202.

† See Plate II. fig. 13 and 14.

hills within its area. The valleys are usually cut down to the slaty forest marble beds and their associated clays.

On the north, and east, and south, it is entirely surrounded by, and dips beneath, the Oxford clay; on the west it is terminated by the back-water of the Fleet, cutting it in an oblique line for about four miles, from the village of East Fleet to the Swanery of Abbotsbury. It has been already stated, that it constitutes the axis or central arch of the Weymouth district, upon each side of which, as on a saddle, all the more recent formations successively repose.

After a slight depression beneath the surface at Abbotsbury, the forest marble and its clays, or in most cases the clays without the marble, reappear in strength in the Vale of Bredy, occupying an extent of surface about eight miles long and four miles broad; bounded on the east and north by the overhanging escarpments of chalk and greensand; on the south by the sea and Chesil Bank, and on the west by the subjacent strata of inferior oolite near Burton Bradstock and Bridport. Throughout all this Vale of Bredy, the main dip of this strata is towards the north.

Inferior Oolite.

Along the whole coast of Dorset, and indeed the whole south coast of England, there is a total absence of Bath oolite; but the inferior oolite occurs in the vicinity of Bridport, attaining a thickness of about 300 feet, and occupying the cliffs for two miles east, and three miles west, of Bridport Harbour. The summits of the highest hills around the town are composed of the superior strata of this formation, consisting of coarsely oolitic yellow limestone, resembling that of Dundry Hill near Bristol, irregularly interspersed with oolitic grains of hydrate of iron, as at Bayeux in Normandy: the most extensive quarries in these upper strata of the inferior oolite, are at the summit of Chideock Hill, on the west of Bridport; these are wrought in a light brown limestone full of large and small ferruginous grains; a few beds also abound in minute veins and cells lined with hydrate of iron. One stratum on this hill is in great measure composed of fragments of Pentacrinite, others contain a variety of organic remains,—Ammonites, Nautili, Belemnites, several Pectens, a large Lima, Cucullæa, Plagiostoma, Modiola, several species of Terebratula, and fossil wood*.

Beneath this coarse limestone is a series of brown and yellow loam and sands, highly micaceous, and containing, in their upper region, strata of cal-

* The oolite of Chideock Hill contains caverns, but no bones have yet been noticed in them; in the same oolite beds at Burton Cliff, there are inaccessible fissures filled with diluvium.

careo-siliceous sandstone, and in the lower region interrupted strata of large concretions of coarse sandstone; the lowest strata of this formation become gradually more blue and marly, and at length pass insensibly into the upper marl beds of the lias.

We observed a remarkable fact in some stony masses from the middle region of the inferior oolite at Down Cliff on the west of Bridport, namely, that some of these masses contained an oolitic breccia or conglomerate of rolled fragments of coarse oolite, not differing in character from the strata of which they form a part. The fragments in this breccia are not concretions, but afford unequivocal evidence of having been rolled by water, in the fact that many of them are perforated on all sides by the holes of small Lithodomi, of which holes the lower extremities alone remain, their tops having been worn away by the attrition which has reduced the fragments in which they occur to the state of large subangular pebbles; these fragments must have lain loose in the sea at the time when the Lithodomi perforated their surface, for one side only could have been perforated before they were detached from their native rock; and the perforation of the lower side at least, if not of the other sides, must have taken place in a period intermediate between such separation and the completion of that moderate degree of rounding which they have since undergone. We see at this time on the ledges of the shore at Lyme, between high and low water mark, loose angular slabs of lias recently torn from the subjacent strata, and perforated on all sides by boring Molluscæ, after the manner of the fragments in our oolitic breccia. This perforated breccia at Down Cliff shows a lapse of time to have intervened, in which there was apparently a suspension of the deposition of the inferior oolite; a time in which fragments were torn by the waters from the earlier beds and became inhabited by Lithodomi, and subsequently rolled on the shores, or at the bottom of the then existing seas; they further show that the lower strata of the inferior oolite were at once consolidated to the condition of stone, hard enough to protect Lithodomi and to be rolled to pebbles, before the upper strata of this same inferior oolite formation had been laid over them.

Lias.

The western extremity of our Map includes the upper marl beds only of the lias formation; these are exposed at the bottom of the valleys of denudation round Golden Cap Hill, and on the sea-shore along its base: they are characterized by enormous deposits of Belemnites, and correspond with the *Calcaire à Belemnite* of the French geologists, as the lower and more stony beds of lias at Lyme agree with the French *Calcaire à Gryphite*. One bed at the

base of Golden Cap presents an almost continuous pavement of Belemnites, running for some distance along the shore; these marl beds also contain the remains of Saurians. A detailed description of this lias formation at Lyme having been published by Mr. De la Beche*, we deem it sufficient to refer our readers to that paper.

VALE OF BREDY.

We have already pointed out details of the leading formations of the Vale of Bredy in our description of the westward terminations of the strata that occur in the Vale of Weymouth; we here sum them up in a few words. The structure of the Vale of Bredy is much less complicated than that of the Vale of Weymouth; its strata do not, as there, dip in opposite directions from an anticlinal line, but emerge regularly from beneath the chalk and greensand escarpments of its eastern and northern frontiers, rising to the west and south, until at their western termination they rest on the inferior oolite of Burton Cliff and the hills near Bridport.

Around the eastern and northern frontiers, the greensand constitutes a sub-escarpment to the chalk, and also forms the outlying summits of Abbotsbury Castle, Swyre Knoll, Shipton Beacon, and Hammerdon Hill already mentioned: its southern frontier next the sea, is composed of forest marble and thick beds of clay connected with it; its middle region also (constituting the bed of the river Bredy,) is made up of these same clays, interspersed occasionally with thin stony beds of forest marble. The entire face of this Vale of Bredy is so destitute of roads and sections, and so covered up with grass from the bottom of the valley to the escarpment of the hills, that it is extremely difficult to trace the separation between these extensive clay beds of the forest marble formation, and those which may be made up of the continuations of Kimmeridge and Oxford clays, interposed between the forest marble and the greensand.

EFFECTS OF DISTURBING FORCES.

Having thus far considered the character and extent of each formation which occurs on the coast of Dorset, it remains only to examine the effects that have been produced on them by disturbing forces: these may be divided into five heads; namely,—1. Elevation;—2. Depression;—3. Contortion;—4. Faults;—5. Denudation.

I. Elevation.

The most important feature which pervades the whole Vale of Weymouth

* Geol. Trans. Second Series, vol. ii. Part I. p. 21. Plate III.

is, the arch-like disposition of all the formations it contains; the axis of this arch passes east and west from Weymouth Bay to the Chesil Bank, forming an anticlinal line, on each side of which all the successive strata dip respectively to the north and south. This dip of the strata in opposite directions from the anticlinal line, is represented in the general section, Plate II. fig. 1. It affords, on a larger scale, an example of the same kind of valleys of elevation with those which have been described by Professor Buckland*. The details of these arched strata in the Vale of Weymouth have already been sufficiently set forth. We think there is evidence enough to show that the strata were once nearly continuous and horizontal, and have been elevated to their present position by a force acting from beneath in a line nearly east and west, forming a continuation of the same line of elevation that extends through Purbeck and the Isle of Wight, and parallel to that of the axis of elevation of the Weald of Sussex and Kent. The period of elevation in all these cases was apparently the same, viz. subsequent to the deposition of the London clay, if not of the most recent tertiary strata in the Isle of Wight.

With respect to the analogous axis of elevation, which extends with certain interruptions from the eastern extremity of the Mendip Hills along the coast of South Wales to Milford Haven, it has been shown by Dr. Buckland and Mr. Conybeare that this elevation took place before the deposition of the new red sandstone formation †; the direction of this line deviates from east and west several points towards the north-west.

In these comparatively small instances, as in the elevation of the highest mountains in the world, noticed by M. Elie de Beaumont‡, it seems that the operating forces have been exerted usually in straight lines, and that these straight lines were often parallel to one another; and the fact that the greatest mountain chains are for the most part thus disposed, more especially those which are volcanic, as in the case of the Andes, leads us to refer the elevation of them all to one and the same common cause,—namely, the expansion of elastic vapours bursting upwards in longitudinal cracks along the lines where the least resistance was presented by the incumbent strata§. The comparative insignificance of the elevations we are considering in the South of England, makes no difference in the principles we would apply to explain their origin; they appear to us to be faithful models, representing on a smaller

* Geol. Trans. Second Series, vol. ii. Part I. p. 119. † Ibid. vol. i. p. 210, et seq.

‡ *Annales des Sciences Naturelles*, 1829—1830.

§ The movement of modern earthquakes along straight lines, added to the frequent rectilinear position of volcanic chains, adds still further probability to these conjectures.—See Hall's South America.

scale, the self-same phenomena, which, in more gigantic magnitude, pervade the highest Alps.

In the eastern part of our Weymouth district, we have examples of valleys of elevation, on a small scale, in the three little circus-shaped valleys of Moignes Down, Poxwell, and Sutton Pointz*. All these three valleys are of an elongated oval shape, and so nearly resemble the interior of a Roman circus, that if the basset ends of the strata were cut into benches, the central area would be visible to persons seated on every part of them.

These three small valleys of elevation are on the same straight line, running east and west, parallel to the grand axis of the Weymouth district, and also parallel to two great faults adjacent to them, and immediately to be described†. The western extremity of the first valley touches the eastern extremity of the second, and the second is separated from the third, only for a small space, by a ridge of Portland stone: each of these valleys has only one small lateral outlet for the discharge of its waters; the area of the Moignes Down Circus scarcely descends below the Portland stone: those of the Poxwell Circus and Sutton Pointz Circus descend into the Portland sand and Kimmeridge clay.

In the circus of Moignes Down and of Poxwell, the circumference is chiefly composed of the basset edges of strata of Portland stone dipping outwards in every direction; but the circus of Sutton Pointz, which is much longer and wider than the other two, is surrounded by Portland stone on three sides only, the remaining north side being partially occupied by greensand and chalk, in consequence of its being intersected by the great Ridgeway fault‡. Although the elevation of these circus-shaped valleys must have produced vast piles of fractured strata on the line of elevation, there is no accumulation of such fragments, nor any perceptible quantity of gravel of any kind within their area; the clearing out of all the rubbish which must have encumbered them at the time of their elevation, can only be referred to the contemporaneous or subsequent operations of very powerful denudation.

II. Depression.

Elevations of strata, such as we have been tracing, can scarcely have arisen without simultaneous depressions in the spaces intermediate between

* See Plate II. fig. 2, 3, 4. † See Map, Plate I.

‡ The circus-like inclosure of the Valley of Sutton Pointz is best seen from its eastern extremity at the top of Osmington Hill, at a point on the old road near the western extremity of the Poxwell Circus; the new turnpike road from Poxwell to Osmington, enters the Poxwell Circus by the outlet on its north side, and crossing its shorter diameter, cuts through the Portland stone on its south side, and there enters upon the Purbeck beds, reposing on the back of the Portland stone, and dipping towards Upton. See Plate II. fig. 3.

the lines of elevation; and accordingly our district affords examples of troughs and depressions thus produced in the case of the Purbeck beds lying upon a trough of Portland stone at Upway, and of Kimmeridge clay in a trough of Oxford oolite at Abbotsbury*.

III. Contortion.

At Upway in the quarries west of the Church, we have examples of contortion produced by the elevation of the strata, similar to those represented by Mr. Webster in his drawings of Lulworth Cove and the coves adjacent to it, in the Isle of Purbeck. Throughout the whole Weymouth district, and particularly along the lines of fault, which we shall next describe, contortions of greater or less amount are too numerous to require individual specification.

IV. Faults.

In a district which has been so much dislocated, the elevations and depressions just described lead us to expect still further disturbances in the occurrence of faults; and accordingly we find two very extensive faults on the northern and north-eastern frontier of the Vale of Weymouth, and also two others on the north-west of the Vale of Bredy and near Bridport, besides many minor local fractures.

The two great faults in the Vale of Weymouth, run nearly in a straight line from east to west, parallel to the general axis of elevation of the whole district, and were probably produced by the same forces and at the same time with this general elevation.

We shall call the most northerly of them the great Ridgeway Fault, the other the Osmington Fault. Wherever we examine these faults, we find double evidence of the movement that has taken place; 1st, In the non-accordance of the strata that form the opposite sides of the faults; 2ndly, In the fine parallel lines and vertical furrows resembling the lines and grooves on Slikensides, and often also in the highly polished surfaces of the materials that form the side walls of the fault, showing that these ponderous masses have ground each other with prodigious violence in the act of separation and movement from their original position. The great Ridgeway fault is an upcast fault, elevating, on its south side, into contact with the escarpment of the chalk strata that would otherwise have dipped beneath it, particularly the Portland stone, nearly along the whole line which this fault traverses. The Osmington fault is a downcast fault, throwing down, on its south side, strata

* See Plate II. fig. 1, 6.

of chalk, greensand, and Portland stone, to a position lower than the strata from whose extremities they have been snapped off*.

1. *Great Ridgeway Fault.*

The most important of these, the great Ridgeway fault, extends, without interruption, nearly fifteen miles, from the eastern extremity of our district at Moignes Down, to the sea near Abbotsbury, passing along the great escarpment of the chalk at various elevations, from the top to the bottom of it; the Osmington fault we could trace only about three miles, from South Holworth near White Nore, to Ham Cliff on the north-east of Weymouth.

The first or great Ridgeway fault is one of the most curious and important we have ever seen, in consequence of the variety of instructive sections afforded along its course; these sections we shall describe in the order of their occurrence, beginning at the eastern extremity †. The fault emerges from the chalk formation at Moignes Down Farm, on the north side of the circus of Moignes Down, and brings the truncated lower ends of strata of Portland stone into contact with the truncated upper ends of strata of chalk, both dipping to the north ‡. Here a valley of denudation runs exactly along the line of fault, having its north side composed of chalk, and its south side entirely of Portland stone. The strata have been raised on both sides of this fault, but raised unequally; whence it results, that on the north side the chalk rises towards the fault, whilst on the south side the Portland stone dips towards it, as if plunging beneath the chalk; whereas the Portland stone has been elevated from its original position, relatively, though not absolutely, much higher than the chalk: yet, notwithstanding this fracture of the strata and dissimilarity of substances on the two sides of the valley, the effect of denudation has been so equable, and the removal of the fractured materials so total, that no other features are presented by the surface than those of an ordinary valley of denudation on horizontal chalk.

Our next section § is taken at Poxwell Hill, less than one mile west of Moignes Down Farm. Here the circumstances of the fault on the north of Poxwell Circus are similar to those at Moignes Down Farm, excepting that at Poxwell there has been no denudation on the line of fault. Two miles west of Poxwell in the valley of Sutton Pointz ||, the exact line of the fault is scarcely to be recognised, from the circumstance of the strata on both sides of it being perpendicular. At fig. 5. in Sutton Valley, one mile west of

* See Plate II. fig. 2, 3.
† See Plate II. fig. 1, 2, 3, 4, 5, 6, 7, 12.
‡ See Plate II. fig. 2.
§ Plate II. fig. 3.
|| Plate II. fig. 4.

fig. 4, the Portland stone forms the south side of the fault; and greensand, surmounted by chalk, the north side,—both dipping rapidly to the north.

The theoretical figure (Plate II. No. 12.) is intended to represent by the dotted lines *aa. bb. cc.*, effects that would be produced by denudation extended to different depths along the line of a fault, traversing such strata as occur along this part of the Ridgeway; thus a denudation descending to *aa.* would leave chalk and greensand on the north side of the valley so denuded, and Portland stone on the south; a denudation to *bb.* would give the same section on the north side of the valley, and Portland sand on the south; and in this case it would be difficult to distinguish between these two sands, without the aid of organic remains. A denudation to *cc.* would give again the same beds on the north side, and Kimmeridge clay on the south: examples of all these three theoretical representations are visible in the course of the Ridgeway fault; e. g. On the high crest which separates the valley of Bincombe from that of Sutton Pointz, the Portland stone touches the chalk; the surfaces of both rocks at the line of fault presenting a uniform appearance, and uniformly level line, like the surface of fig. 12. Plate II. Near the north-western extremity of Sutton Valley, a denudation, analogous to that represented by *aa.* fig. 12. Plate II., shows the Portland stone touching greensand; a lower point of the same denudation exhibits the Portland sand in contact with the greensand, as represented at *bb.* in the same figure; and on the north of Sutton village the Kimmeridge clay also is brought into contact with the greensand, as represented at *cc.*

At Upway, on the northern extremity of the general section, and near the summit of the hill*, the Portland stone, covered by Purbeck beds, occupies the south side of the fault, and nearly horizontal chalk its north side, the Purbeck and Portland beds rising at a high angle northwards towards the fault. From Upway, for four miles westward, to the final termination of the Portland stone at Portisham, the Portland stone is continued on the south side, and the chalk on the north side of this fault; it is exposed by no section, but the junction can be traced on the surface of the fields.

Near the village of Portisham, precisely at the western termination of the Portland stone, the fault deviates to a south-western direction for about a quarter of a mile, traversing the bottom of a deep and narrow dry valley or comb, by which the road from Portisham leads up to Black Down; the east side of this valley is composed of Portland stone, and the west side of chalk, both attaining a considerable elevation above the bottom of the valley. In the village of

* Plate II. fig. 1.

Portisham, the fault again resumes its westerly direction, and at the same time brings up the Kimmeridge clay into immediate contact with the base of the escarpment of the chalk; this contact continues for some distance towards Abbotsbury. At Abbotsbury*, the Oxford oolite occupies the south side of the fault; and greensand, resting upon clay, the north side; the two latter are nearly horizontal, whilst the oolite rises to the north.

The irregularities of structure occasioned by this fault on the west of Abbotsbury are considerable, and not totally made out by us. A compound disturbance, similar to that which has produced the trough-shaped disposition of the Purbeck and Portland stone at Upway, has caused an analogous derangement near Abbotsbury, along a tract of about a mile in length, from east to west, and nearly a mile in breadth†. This tract occupies the slope and under-terrace, between the summit of Abbotsbury Common and the sea, and is composed chiefly of ferruginous Oxford oolite, dipping regularly towards the north, on that side of Abbotsbury which is nearest to the sea, until it terminates abruptly in a hill called Zoles (immediately above the mansion of the Countess of Ilchester). In this hill it suddenly trends round, changing its dip towards the east, and rising with an escarpment to the west, for a short distance, until the dip again turns suddenly to the south, and so continues along the line of fault, running east and west more than a mile from Zoles to the town of Abbotsbury. By these three dips, the oolite is thrown, at its termination, into the form of a spoon, rising outwards in three directions from the lowest central line of depression, and terminated by high escarpments on the south and west, and on the north partly by a false escarpment‡, and partly by abutting against the fault§.

The existence of this false escarpment (fig. 7.) is due to the agency of the upcast fault, which has elevated, not only these Oxford oolite beds, but even the subjacent beds of Oxford clay and forest marble irregularly along the under-terrace, between the false escarpment of oolite, and the true south escarpment of the lofty ridge of greensand and chalk composing Abbotsbury Common; so that beneath and parallel to this true escarpment, at a distance varying from one to two furlongs, the false escarpment forms a broken under-terrace|| facing the true escarpment, with opposite dip; and between these two escarpments a narrow band of forest marble is thrown up in great confusion for about a mile, from the town of Abbotsbury west to Zoles. The confusion is increased by land slips, which have brought down heaps of rubbish from the greensand escarpment of Abbotsbury Common and Abbots-

* Plate II. fig. 6. † See Plate II. fig. 6 & 7. ‡ Plate II. fig. 7.
§ Plate II. fig. 6. || See Plate II. fig. 7.

bury Castle Hill, and spread them over the various broken beds of the oolite formation, along the under-terrace and line of fault; and have also so completely masked and covered up all the lower beds of the true escarpment below the greensand, that not one of them can be distinctly seen: and although this great escarpment is at least 400 feet above the sea, none of its lower strata are exposed to view, except a bed of clay, which, by casting out a line of springs along its junction with the incumbent greensand, affords a perpetual cause of the land slips which obscure the entire base of this escarpment, and prevent our tracing distinctly the great Ridgeway fault at its western termination into the sea*.

The depth of the dislocations occasioned by this great Ridgeway fault along the escarpment of the chalk appears to vary to the amount of several hundred feet.

2. *Osmington Fault.*

The range of the Osmington fault is east and west, and parallel to the great Ridgeway fault we have just described, at the distance of about one mile and a half to the south: its eastern extremity is lost in the chalk downs near South Holworth, and its western termination is seen in Ham Cliff, three miles north-east of Weymouth. Plate II. fig. 2. exhibits its most eastern section at Upton Hill, in which horizontal chalk beds form the north side of the fault, and subsided chalk, greensand, and Portland stone, the south side: a lime-kiln excavated exactly on the line of fracture, exhibits the disposition here represented. In a section of the hill and water-course, one mile further west, at Osmington Mill†, the south side of this fault is formed of subsided chalk and greensand, dipping north; and the north side formed of chalk, resting on greensand, both inclined slightly to the south. Plate II. fig. 8. shows the western extremity of this fault at Ham Cliff, where the Oxford oolite on its south side has subsided to the level of the Oxford clay on its north side.

3. *Ringstead Bay Fault.*

Plate II. fig. 11. represents a third and very local small fault, produced apparently by a fracture in the cliffs, and bringing a subsided mass of Portland stone and Portland sand into contact with Kimmeridge clay. This fault is more oblique than any part of the two great faults we have been describing; like them it ranges east and west, but can be traced only to a

* On the north side of Abbotsbury Common, immediately below the Castle, a series of land slips, similar to those on the south side, is indicated by a long range of narrow ponds, supported by the bed of clay, across which the land slips have taken place. † Plate II. fig. 3.

very short distance: the pseudovolcano we have described is in the Kimmeridge clay which forms the base of this subsided mass.

Another minor fault is seen at Boat Cove, on the west of Osmington Mill*, where an apparently false dip of the Oxford oolite has been produced by a recent slip of the cliffs; it is so small and partial that it would be unworthy of notice were it not that it is prominently exposed in the profile of the coast, and gives an erroneous impression of the position of the strata in the cliff from which it has fallen. Near this spot, also, at the cascade of Osmington Mill, we have another small fault, exposed on the shore traversing the Oxford oolite, and running outwards into the sea, just along the anticlinal line, where the strata turn at this part of the coast†.

4. *Bothenhampton Fault.*

Pl. II. fig. 14. represents a downcast fault at Bothenhampton, one mile south-east of Bridport. We believe that this fault was first noticed by Prof. Sedgwick: it is of considerable depth, bringing the forest marble on its south side into contact with inferior oolite on the north side, the forest marble dipping at a considerable angle towards the fault; its general range, like that of the rest, is nearly east and west, and although, from the similarity of the clays which it intersects, we have not traced its uninterrupted connexion, we think it continues eastward to Shipton Gorge, Litton Cheney, and Long Bredy. At each of these three places, lying as they do nearly on a straight line, there has been much dislocation and disturbance.

5. *Bridport Harbour Fault.*

At Pl. II. figures 13 and 14 represent the western termination of another downcast fault in the cliffs about a mile west of Bridport Harbour, being the last we have to mention. Its amount is considerable: on its north side are beds of inferior oolite based on lias; on its south side are beds of forest marble based on more than 150 feet of grey clay, and these are suddenly and violently turned up when they come into immediate contact with the fault. We believe this clay to be the same that occurs in such thickness in the Vale of Bredy; and although we have there considered it as subordinate to the forest marble formation, we have no evidence to show that it may not also represent the Fuller's earth beds that occur between the great oolite and inferior oolite of the neighbourhood of Bath. The eastern extremity of this fault‡ presents a complicated double fracture, causing the lower beds of the

* See Plate II. fig. 9. † See Plate II. fig. 9. ‡ Plate II. fig. 13. *a*.

grey marl and marlstone to assume a position partly vertical and partly tortuous, between horizontal beds of grey marlstone on the one side, and of inferior oolite on the other. These appearances may in part be due to subsidence superadded to the fault; the point of the cliff in which they occur is so much exposed to the action of the waves, that it may ere long be totally removed, and the appearances represented in our section be entirely changed.

It should be observed that not one of all these faults appears to have been produced during the formation of the strata: not one is covered at its summit by any overlying substance except diluvium; and that those in the eastern part of our district were evidently not produced until the time at which the chalk and all the strata subjacent to it, in this district, underwent a simultaneous elevation.

V. Denudation producing Valleys.

In a country that has been the scene of such tremendous convulsions and subterranean disturbances, it was probable that we should find on the surface abundant ruins, and dislocated fragments of the rocks that have been submitted to such violence; we should expect to discover masses of rubbish such as we see in the wreck of modern land slips, and which cannot but have been created in prodigious quantity along the line of the elevations and fractures we have been tracing: but on examination we find that all this wreck has vanished, and been so totally swept away, that scarce a trace of it can be recognised throughout the whole district which it must once have covered.

It is obvious, from a mere glance at the Map, that the strata originally occupied larger areas than they cover at present; and that if no further operations had taken place in the Vale of Weymouth beyond the elevation and fractures we have described, we should have had little more than a series of arches piled successively on one another, and extending over a large portion of the whole district; the angle at which the strata rise being in many parts so small that no very distant separation of the fractured parts could have attended their elevation; and thus the central cornbrash of the Vale of Weymouth would have been arched over with bending strata of Oxford clay, coral rag, Kimmeridge clay, and Portland stone; and the Vale of Bredy and the Bridport district would have been covered by nearly horizontal beds of greensand and chalk, connecting the great greensand escarpment of the north and east of the Vale of Bredy and Abbotsbury Castle with the outlying summits of Swyre Knoll, Shipton Beacon, Eype Down, Golden Cap Hill, Lewsdon Hill, Lambert's Castle, and the entire group of insulated caps and ridges of green-

sand and chalk near Charmouth, Lyme, and Axminster. But as no such arches exist in the Vale of Weymouth, nor any such continuity of the greensand strata in the vales of Bredy and Bridport, we cannot but infer that some adequate cause has produced the removal of the vast masses of materials which apparently must once have filled the spaces that are now left void; and we see no cause adequate to the production of such an effect, except the denuding power of a mass of moving waters; a power which has removed more than it has left of the entire bulk of nearly all the strata that appear on the surface of this district, excepting the chalk.

Again, if we look for traces of ruin and violence on the surface along the lines of fault, we find no such indications presented to us; but however great may have been the dislocation and subterraneous changes of level, the outlines of the surface are little affected by these changes: thus, our sections Pl. II. fig. 1, 2, 3, 4, 5, and 6, afford examples of the summits and sides of hills where we should be utterly unconscious, from the external form of the land, that the least derangement or fracture has ever affected the subjacent strata; the general outlines are regular and rounded, as if no violent movements had ever occurred below, and all the ruins and piles of rubbish that must have been produced along the lines of elevation and fracture are swept clean, clear, and smooth away.

If we traverse the great Ridgeway fault for fifteen miles, from one extremity to the other, we see along the whole surface scarcely an indication of its existence. Near Upway we have an obvious example of this fact, at the point where the road from Bridport passes down the chalky escarpment of the Ridgeway through one of those broad and sweeping dry combs which are so common in escarpments of chalk: having descended nearly to the bottom of the hill, where we should expect the outcrop of inferior chalk or greensand, we are surprised to find Portland stone rising to the north, and abutting against the chalk; yet we see not the slightest change in the outline of the surface on either side of this line of fault, nor is there upon its south side a single remaining fragment of all the masses of greensand and chalk that must have been elevated into a new and high position on that side of the fault when the fracture took place; all traces of the enormous ruins that attended this great convulsion have utterly vanished and been swept away; so that scarcely the residuum of an outlying fragment remains to attest the catastrophe that has taken place: the sloping sides of the combs glide regularly and gently down, as if they had been excavated in one undisturbed and uniform mass of continuous chalk. Nor is this outclearing and total removal of the broken fragments peculiar to this comb on the north-west of Upway; it is equally ap-

parent in many others along the whole extent of the fault, particularly in the deep combs of Elwell, Bincombe, and Sutton Pointz, that lie successively adjacent to Upway on the east.

The deep and numerous dry valleys on the surface of the chalk hills that bound our district partake of the general character of such valleys on the surface of the chalk formation throughout England; and have no peculiar features beyond those which they have derived from enormous volumes of water, retiring in all directions from the higher to the lower levels, and acting at all elevations and on all points to modify the previous forms of the surface of the earth.

If we look for the cause of all this removal in any natural operations now proceeding within the district, we find not the shadow of any satisfactory explanation of that vast destruction of which it has been the scene. It is vain to appeal to the action of rivers, for in many parts where the denudation has been greatest, there is not even a streamlet, or a single spring. The greatest streams we have in the district are the two insignificant rivulets of the Wey and Bredy*. It is equally vain to appeal to meteoric agents, for we have a measure of the total amount of their effects in the fragments accumulated in the form of talus and land slips at the bottom of certain slopes and precipices, and in a few small accumulations of mud and sand in the low grounds.

The only satisfactory solution we can find is in the waters of a violent inundation, and in these we think we see a cause that bears a due ratio to the effects that have been produced.

* The only river in the Vale of Weymouth is the small stream of the Wey, which, rising suddenly at Upway, from a cross fracture in the Portland beds, runs about five miles from north to south, into the sea at Weymouth, crossing nearly at right angles all the different formations, as well as the hills and valleys that occur along its course, and receiving only a few tributary confluents from the west. The Vale of Bredy is traversed by the small river of that name, running west from the village of Little Bredy to the sea at Burton Bradstock. It is impossible to refer the excavation of these deeply denuded valleys and the removal of the broken strata to the flood waters of such streamlets, or to the agency of their waters accumulated into lakes by any imaginable series of barriers, which the bursting of such lakes may be supposed to have removed. The east and west portions of the elliptical valley of Sutton Pointz offer a good example of denudation, independent of rivers. The only stream within this valley rises on its northern side, upon the line of the great fault at the base of the chalk escarpment, and running direct across the shorter diameter of the valley, escapes through a broad denudation, which intersects the Portland stone that forms the south side of the ellipse. (See Map, and Pl. II. fig. 4. 5.) We have a measure of the small amount of the excavating power of this streamlet cooperating with meteoric agents in a ravine five or six feet deep, and a few yards long, which the water has cut in a talus of chalk rubble, in which it begins its course. A similar ravine of much greater length, and about twenty feet deep, which occurs at the base of the chalk escarpment, on the south of Wantage, is there cut through

How far the causes of this inundation may be connected with the elevation of the strata in the immediate neighbourhood or in distant regions, is a subject which at present we conceive it premature to enter into, further than to suggest that the relation of the one to the other may possibly be nearer than has been hitherto apprehended.

Diluvium.

Although the excavation of valleys of denudation, and removal of broken strata has been so considerable in all this district, we have no proportionate accumulation of extensive and continuous beds of gravel. The power and rapidity of the currents which could excavate the materials that filled such enormous spaces must have been too great to allow these materials to subside so near the spots from which they have been torn away, and must have drifted them far forwards into the prolongation of these valleys in the bottom of the English Channel, whence perhaps many of them may have been cast up again, and have contributed to form the Chesil Bank. The largest deposit of diluvium we have noticed is at Upway Street, four miles north of Weymouth; but in smaller quantities and irregular patches it is disposed over the whole surface of the country, on the summits and slopes of the hills as well as in the valleys.

We have not heard of many organic remains in the diluvium of this district, but the following are sufficient to show their identity with those found in diluvial gravel in other parts of England. A few years ago a large rolled molar tooth of an elephant was cast upon the Chesil Bank, from the diluvium

the chalk-marl with such regularity as to present the uniform width and uniform grassy slopes of the deep foss of a military fortification, and affords a similar measure of the amount of the power of existing agents on a substance of such uniform and perishable materials as soft chalk-marl.

The following list of the temperature of springs in the neighbourhood of Weymouth was taken by Professor Henslow, with a good thermometer, in the year 1832:—

20th August. Well at Chesilton, in Portland stone, near the middle of the ascent in the yard of the Portland Arms. A pump was used ..... 54° 0′

24th August. Spring at Preston, by the road side, in the Portland sand ..... 53° 0′

28th September. Large spring at Upway, the source of the river Wey, rising suddenly in great force from a cross fracture of the Portland rock ..... 51° 0′

20th Septemper. Pump at Corfe Castle ..... 52° 5′

20th September. Hill side (vertical strata), half way between Corfe and Worbarrow Bay, junction of chalk and sands ..... 52° 0′

4th September. Top of Headon Hill, Isle of Wight: spring from the upper freshwater formation, a few feet from the summit ..... 50° 0′

5th September. Spring issuing from the sand rock under the fire-stone at Knighton.... 51° 0′

Where the temperature was taken in pump-water, it was not done until all the water that had filled the pipes was removed by long pumping.

beneath the sea, and is preserved at Abbotsbury by the Countess of Ilchester. Near Bridport also, at the villages of Burton Bradstock and Loders, the gravel has afforded the remains of elephants and other terrestrial quadrupeds. In the gravel that crowns the cliffs of lias, near the church of Lyme Regis, many teeth of rhinoceros have been found, and portions of the tusks of elephants; and lastly, the cliff at the south termination of the valley of Charmouth, where, as at Lyme, the lias is covered with a cap of diluvium, has afforded several nearly perfect tusks of elephants which tumble from the summit and get mixed with the debris of lias, when masses of the cliff are undermined, and fall down on the sea shore. A tusk nine feet eight inches long, from the gravel of this cliff, was some years ago in the collection of Mr. De la Beche, and is now in the Museum of the Geological Society*. Two molar teeth of elephant, one weighing twelve the other thirteen pounds, were found in this same cliff, in December 1832.

Conclusion.

We shall conclude with pointing out the following general results that appear deducible from the facts we have been considering. We conceive that we have before us sufficient evidence of the following succession of changes in the state of that small portion of England which occupies the coast of Dorsetshire. They are analogous to those deduced by Mr. Mantell from the phenomena he has described in the weald of Sussex.

1st, We have a succession of marine deposits, continuous from the lias upwards through the oolites, and terminating in the deposition of the Portland stone; during the period of all these formations our district must have been the bottom of an ancient sea: the presence of the remains of trees in the oolite and lias shows that land existed probably at no great distance from this sea; it is also probable that the waters were not very deep, in which Plesiosauri were so abundant as they must have been, to supply such numerous remains as we find imbedded in the lias at Lyme.

2ndly, The bottom of this sea appears for a certain time to have become dry land, and whilst in this state, to have been covered with a forest of large coniferous trees, and of Cycadeoideous plants that indicate a warm climate. We have a measure of the duration of this forest, in the thickness of decayed vegetable matter and soil, which has accumulated more than a foot of black earth around the roots of these trees. The regular and uniform preservation of this thin bed of black earth over a distance of so many miles, shows that

* See Geological Transactions, Second Series, vol. i. p. 421—422.

the change to the next state of things was quiet and gradual; since the trees that lie prostrate on this black earth would have been swept away had there been any violent agitation, or sudden irruption of water.

3rdly, The dry land on which this forest grew became converted to something like an estuary, in which the lowest deposits contain freshwater shells; these are succeeded by a thick bed of oyster shells, and above the oyster bed are strata containing an admixture of freshwater shells with shells that are marine.

We have evidence that this formation extended eastward from what is now the coast of Dorset, through the Isle of Wight to the eastern extremity of the weald of Kent; but of the boundaries of this supposed estuary we have not the slightest indication beyond that which is afforded by the existing deposits of Purbeck and Wealden freshwater formations.

The occurrence of the Purbeck strata reposing on the Portland stone at Lady Down near Tisbury, on the west of Salisbury, in a position directly north of the Isle of Purbeck, at the distance of about thirty miles, renders it probable that the breadth of the estuary in this part extended over the intermediate portions of Dorset and Wilts, which are now covered up with chalk.

4thly, We have a return of the sea over our estuary; and in this sea an accumulation of the successive and thick marine deposits which constitute the greensand and chalk formations.

5thly, We have in the Isle of Wight a reappearance of freshwater deposits mixed and alternating with others that are marine, through the next great periods of the tertiary formations.

6thly, All these deposits appear to have been succeeded by a tremendous catastrophe, producing elevations, depressions, and contortions of the strata; and intersecting them with enormous faults.

7thly, These movements of the land have been succeeded by inundations, competent to excavate the valleys of denudation, and partially to overspread the country with diluvial gravel.

8thly, This denudation has been followed by a state of tranquillity, which has remained undisturbed to the present hour.

II.—*Introduction to the general Structure of the Cumbrian Mountains; with a Description of the great Dislocations by which they have been separated from the neighbouring Carboniferous Chains.*

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(woodwardian professor in the university of cambridge.)

[Read January 5, 1831.]

§ 1. *Introduction.*

I HOPE, in a series of communications, of which this may be considered the introduction, to lay before the Society the results of observations made principally during the summers of 1822, 1823, and 1824, among the Cumbrian mountains, and the neighbouring districts of the North of England. All the central portions of the region, I propose hereafter to describe in detail, is composed of rocks of a date anterior to the old red sandstone, but its outskirts are covered by deposits chiefly of the carboniferous order. On the west side it is washed by the Irish Sea; and on the east it presses against, and, in part, blends itself with, the great calcareous chain which forms the separation of the waters descending to the coasts of Lancashire and Yorkshire. To the north it is prolonged, through an unbroken zone of mountain limestone, into the plain of the new red sandstone, stretching down the vale of the Eden; to the south it sinks towards the shores of Morecombe Bay, and terminates in a succession of flat-topped elevations, crowned with precipices of mountain limestone—the remains of a calcareous ridge, once undoubtedly continuous from the higher part of the valley of the Kent to the southern extremity of Cumberland.

It follows, from this description, and will be still more clearly seen by a glance of the eye over the north-west part of the geological map of England*, that the circular cluster of the mountains here described, presents, through the greater portion of its circumference, a nearly unbroken band of mountain limestone; and on whatever side it is approached, we are struck with the tameness of the outline of every portion of the calcareous zone, when contrasted with the fine serrated peaks of the loftier and more central elevations.

* A new edition of Mr. Greenough's Geological Map of England is now in progress, and will be shortly published.

From some of the ridges in the range of Cross Fell, the eye takes in, at one view, the greatest part of the northern calcareous zone. Seen from that distance, all its minor inequalities disappear, and I have often fancied that it resembled a portion of a great semicircular redoubt formed near the base of the older hills, and presenting a long, sweeping, irregular glacis towards the valley of the Eden. On a nearer approach, an illusion of this kind must necessarily vanish, and I only mention it in this place to convey a general idea of the external characters of the district, and of the relations of the great formations to each other.

On the eastern side of the region, where the older rocks abut, as above described, against the great central calcareous chain, the contrast of external forms is perhaps still more striking. The calcareous mountains, though sometimes cut down into mural precipices, and having individual features of the greatest beauty, and, though rising to such an elevation as to overlook the more ancient formations in their immediate neighbourhood, seldom exhibit any grandeur of outline, and in consequence of the horizontal position of their beds, often terminate in great featureless and somewhat tabular masses. On the contrary, the greywacké hills on the confines of Yorkshire and Westmoreland have their sides worn down into deep combes and irregular sinuosities, and sometimes rise into sharp angular crests, forming outlines of great variety and beauty.

Within the calcareous zone above described are several extensive masses of granite, syenite, and porphyry; but the greatest part of the region is occupied by stratified deposits of a slaty texture, which may be subdivided into four distinct formations. 1st, Various crystalline slates, resting immediately on the granite of Skiddaw Forest, and forming the base of the whole stratified series. 2nd, Black glossy clay-slate, sometimes passing into greywacké, but containing no calcareous beds, and no organic remains. 3rd, Green quartzose roofing slate, associated, in every variety of complication, with felspathic rocks of porphyritic structure. This formation contains many beds effervescing briskly when first plunged in acids; but it contains no continuous bed deserving the name of limestone, and no organic remains. 4thly, Greywacké slate, often more or less calcareous, and having subordinate beds passing into impure limestone, full of organic remains.

We owe our first accurate knowledge of these subdivisions to Mr. J. Otley of Keswick, who not merely described them in general terms, but gave their geographical distribution with a very near approximation to accuracy*.

* See an early Number of the "Lonsdale Magazine," and "A Guide to the English Lakes," by Jonathan Otley of Keswick.

In subsequent communications I hope to prove: 1st, That the crystalline unstratified masses form the true geological centres of the mountain groups; and that by their protrusion the schistose formations have been elevated into the position they now occupy. 2ndly, That a true mineralogical axis may be traced through the inferior divisions of the slate rocks on each side of which the successive formations, as far as they are clearly developed, are arranged symmetrically. 3rdly, That the beds of these formations, when we exclude irregularities arising from local causes, have a nearly constant strike from a few degrees north of magnetic east to a few degrees south of magnetic west. And, lastly, That all these peculiarities of structure and position originated in causes brought into action at a period anterior to the existence of the old red sandstone.

On these several subjects I wish, for the present, to avoid any further details: I may, however, be permitted so far to anticipate the materials of a future communication as to describe the range of the remarkable calcareous beds, interposed between the green quartzose roofing slate and the greywacké slate. Such a description will place in a clear point of view the kind of evidence by which we determine the *strike* of the slaty masses, and will at the same time make us acquainted with a succession of dislocations which have considerably modified the external forms of the Cumbrian mountains. It will also form a natural introduction to the description of a second system of dislocations, by which, at a later geological epoch, these older mountain groups were snapped off from the central carboniferous chain, and brought into their present almost insulated position.

§ 2. *Range of a band of Limestone and Calcareous Slate, between the Quartzose Green Slate and the Greywacké Slate, &c. &c.**

This band is full of organic remains, and is separated by masses of enormous thickness from all other calcareous strata with which it could possibly be confounded: moreover, it occupies, as before stated, a place intermediate between two entirely distinct formations. Hence, although varying in thickness from 30 or 40 to 200 or 300 feet, it can be easily followed; and in the places where its continuity has been broken by great internal movements, we can generally, in imagination, reunite the disjointed portions, and calculate the amount of their dislocation, without running the very common risk of mistaking one bed for another.

The most western appearance of the limestone is at Beck, a farm in the

* See Plate IV.

division of Cumberland called Millam. Thence it ranges through Corn Park, over the Knot, into the Low House grounds; and, after crossing a marsh, reappears in the same range above Water Blain, and terminates at the foot of the village called Hill,—the mean bearing of the beds in the whole of this range being about north-east by east, and the dip south-east by south.

Here we lose all trace of the limestone; but after ascending several miles up a rivulet, we find, immediately above Graystone House, among the hills to the east of Duddon Bridge, a bed of limestone, identical in dip and range with the one we had left behind. Moreover, the Graystone House limestone is very nearly in the exact prolongation of the band of transition limestone on the other side of the Duddon. Hence we may conclude that the Graystone House and Water Blain limestones belong to the same formation, and have been severed by an enormous fault, descending nearly in the direction of the valley of Hallthwaite. The quantity of dislocation estimated in the direction of a perpendicular to the two parallel lines of bearing cannot be less than two miles*.

Such a disruption of great mountain masses is not a little startling to the imagination; but I may state, by way of explanation, that many of the neighbouring mountains are penetrated by dykes of porphyry and syenite, probably of the date of the eruption of the Bootle granite, and that the whole region of Black Comb, which belongs to the oldest slate formation, has probably at the same period been thrust out of the bowels of the earth, and elevated into a position out of all symmetry with the structure of the neighbouring region. The country between Millam and Duddon Bridge is, therefore, one where we ought to look for the evidence of enormous dislocations; and this evidence is placed before us in the most impressive manner by that break in the continuity of the limestone, and that great lateral movement which I have just described.

The beds of the Graystone House limestone would, in their prolongation,

* It is right to state that there is a difficulty in identifying the Graystone House and Water Blain limestone, arising out of the mineral character of the overlying slates. In general we can easily separate, even by hand specimens, the greywacké slate of the highest group from the green slate under the limestone. But at Graystone House this is not possible, as the overlying slates are in structure almost identical with those of the inferior group. Hence some one might conclude that the Graystone House limestone formed no part of the calcareous band described above, but was an accidental mass subordinate to the series of the lower green slate. There is not, I think, much force in the objection; for there are other places where portions of the two slate groups cannot be mineralogically distinguished: and, after all, it merely shifts the difficulty, as we shall have (on this supposition) to interpolate an enormous fault, somewhere on the line of the Duddon, in order to explain the position of the corresponding calcareous bands on the opposite sides of the river.

strike the south end of the range of hills on the north-east side of the Duddon; the limestone is not, however, found in those hills, but appears, with its usual characters, and the same mean line of dip and *strike*, in the lowlands on the east side of the ridge. From this I conclude that a break of the strata passes down the valley of the Duddon, accompanied with a lateral movement, not however comparable in extent to the one last noticed. The further range of the limestone is well defined by the following localities, viz. Hartley Ground, Lum Holm, Broughton Mill, and thence up the bed of the river to Stockbeck*. The limestone preserves an undeviating strike and dip; and in consequence of the sinuosities of the channel, is seen, here and there, above the mill, on different sides of the river. At Stockbeck the river bifurcates, and the limestone runs along the north-west side of the eastern branch, close to Appletreethwaite, where there is a transverse fault, throwing the prolongation of the limestone, about a hundred yards further to the north. This apparently lateral movement has no effect on the direction of the beds, which preserve an almost perfect parallelism; but it produces a slight deviation in the direction of the rivulet.

From Appletreethwaite the limestone continues its course (about 70° or 75° east of magnetic north), and making a very slight deflection to the northeast, passes on that side of Ash Gill quarries. Thence ranging over Torver Fell, and across the rivulet, it passes along the line of the Seathwaite road, and reaches one of the flanks of Coniston Old Man; up which it rises to a considerable elevation, and in a plane nearly parallel to the steep side of the mountain. On reaching the north side of Broadway Beck (one of the streams descending from the mountain), the limestone is again cut off by a great transverse fault, which appears to throw it to a point about 300 yards southeast of its line of bearing.

After reappearing in Scrow pastures, it ranges through a wood, descends down the north side of Mealy Gill, passes close to Old Mill, south of Silverbank, and thence close to the road, and at the foot of a great precipice, to Low Yew Dale, from which place it is prolonged across the low grounds to a point close to Yew Tree. Here it is cut off by the great precipice of Raven Crag, and a vast transverse fault has pushed whole mountain masses of green slate

* There can be no doubt of the identity of the Millam limestone with that which ranges through the places enumerated in the text. Hence (though the Graystone House limestone, in consequence of the difficulty alluded to in the preceding note, be excluded from the range), we must at least suppose that the Water Blain and Hill limestone bands were once continuous with that of Hartley Ground. But this supposition is quite incompatible with the general *strike* of the beds, unless, as stated in the preceding note, we interpolate an enormous fault along the line of the Duddon.

and felspathic rock so far out of their line of bearing, that we are compelled to make a southern traverse to a knoll above Coniston Hall (a distance of more than a mile), before we can discover the broken ends of the beds of limestone. The line of fault appears to be prolonged down the valley, nearly in the direction of Coniston Water Head.

From the knoll above mentioned the limestone ranges, with a slight deviation from its mean direction, through the hills which overlook the Tarns, and descends to a point, close to the separation of the Skelwith and Ambleside roads. Here the great masses of green slate, which had before encroached on the *strike* of the beds, are suddenly thrown back at Pool Beck Scar, and the limestone beds are cast, at a single heave, about a mile and a half to the north of their former line of direction. This enormous fault, though it produces a considerable influence on the configuration of the neighbouring country, is in one respect an exception to a general rule, inasmuch as its direction is not marked by any valley.

In this part of the range the country is much covered with alluvial matter; but the continuation of the line is nearly defined by the lime quarries of Holmes House, the beds under Pool House, and the old limeworks on the north shore of Pool Wyke. Seen from Pool Wyke the quarries of transition limestone on the east shore of Windermere are not more than 10° north of true east; but had they been on the prolongation of the mean line of range, they would have appeared about 35° north of the same point. From this we may, I think, conclude, that there has been a break between the opposite shores of the lake—that the beds, on the east side, have had a considerable movement towards the south—and that the valley of Windermere, like all the other great valleys cutting through the limestone range, has been scooped out upon a line of fracture.

From the quarries about 400 yards above Low Wood Inn, on the east shore of Windermere, the limestone beds range through the woods, and pass just under Dove Nest, and on the north side of High Skelgill, near which place they are expanded over a considerable surface, the rise of the mountain side being nearly parallel to the plane of stratification. They are prolonged in a direction a few degrees *north of magnetic east,* through the extreme ramifications of the rivulet which runs down to Low Wood, and thence to the top of the hill overhanging the village of Troutbeck. From this point the range of the limestone on the opposite side of the valley, near the high pass leading to Kentmere, is distinctly visible, and bears about 15° *south of magnetic east.* Now this change of bearing is exactly the opposite to that which might have been expected; especially after remarking the great elevation of

the pass before mentioned: for the beds being all inclined at a great angle, and rising to the north-west, we have reason to look for the most northern portions of their range at the points of highest elevation. This fact makes the change of bearing above mentioned still more striking, and convinced me, before I descended from the hill, that there was a great fault ranging down the valley of Troutbeck.

On this subject we are not left to mere inference, for the limestone beds descend the hill on the north side of the village, range through a point about 150 yards above the junction of the two roads, and are traced to a small coppice near the river side, called Intake Wood. Near that place they are cut off by a fault ranging down the river, which has caused a great movement towards the south in the whole system of beds on the opposite side of the valley. We are therefore compelled to descend about three quarters of a mile before we can catch the broken ends of the beds we have left behind.

After being concealed in the alluvion of the valley, the beds again break out behind Line Foot, and, ascending rapidly towards the north, with the inclination of the hill, pass for some way on the north side of the Kentmere road. At the top of the hill they range on the south side of the road, in a direction difficult to ascertain in such uneven ground, but approaching magnetic east. In descending the hill towards Kentmere Hall they appear to be dislocated, and shattered by a complication of faults, and one great mass ranges down the brow, in a direction about 45° east of magnetic south. This very anomalous bearing is accounted for partly by the movements of dislocation, and partly by the great angle of dip and inclination of the surface. Another disjointed mass of limestone ranges nearly in the mean bearing behind the Hall, but is cut off by a fault before it reaches the chapel. Lastly, the beds in regular order, beyond the faulty ground, cross the rivulet (with their usual dip and *strike*) about 400 yards above the bridge, through the fields of Head Lane farm.

From this place the beds rise into a ravine in the edge of Pike How, and thence over the top of the hill, through a point about 200 yards south of the mountain road to Long Sleddale, and so down the hill to a place called Till's Hole. By taking, from Till's Hole, the bearing of the corresponding beds on the other side of Long Sleddale, we find that the limestone strikes the opposite hills at a point several degrees out of its previous bearing; which fact probably indicates the passage of a fault also down this valley. Everything is however obscured by alluvion near the banks of the river; and if there be any shift of position among the mineral masses in their strike across the valley, it must be of comparatively small extent.

On the east side of Long Sleddale the beds of limestone are seen crossing a rivulet, about 200 yards above the houses called Little London; and from that place they may be traced up the southern branch of the same rivulet (called Iron Crow Gill), for nearly half a mile, in a direction about north-east by east. They then disappear under great accumulations of turf-bog, and alluvial matter, and are not again seen. Some peculiar felspathic rocks on which they rest, and some thick beds of blue flagstone, by which they are surmounted, may however be traced through a morass on the top of the mountain: there can, therefore, be little doubt that the limestone beds are also continued past the north side of a hill called Lord's Seat, and thence into the turf-bogs on the east side of Yarlside Crag, to a place not more than a mile and a half from Wastdale Head.

Had this system of strata met with no interruption, it would, after a further range of about four miles, have abutted against the zone of mountain limestone. It is, however, cut off by a great boss of granite, which has deranged the relative position, and changed the mineral structure of all the neighbouring rocks: from which we may, I think, safely conclude, that the granite of Wastdale Head (commonly called Shap granite), did not assume its present position till some period after the formation of the transition limestone.

I have been the more minute in these details because they enable us clearly to establish a series of important facts in the geological history of the Cumbrian mountains.

First. They prove, that at a very ancient epoch, and probably during the principal period of elevation, great cracks were formed, diverging from the centre of the mountains, accompanied by great changes in the relative position of the mineral masses on the opposite sides; and further, that these cracks prepared the way for future valleys*. Now the principal valleys of these mountains diverge towards all parts of the circumference, from a centre near the high crests of Sca-Fell. Is it not, therefore, probable (though in the absence of beds of limestone, like those above described, we cannot establish the fact on direct evidence), that great lines of dislocation pass down the greatest number of these valleys? In making this supposition we merely

* The usual appearance, on the opposite sides of the faults above described, is exactly that of a great horizontal lateral movement, and is not, I believe, by any means entirely deceptive; for expansive forces of elevation acting on oblique planes, might easily produce such a movement. The effect was probably of a compound kind. When beds are highly inclined, a mere subsidence on one side of a fault will, however, produce on the surface the exact appearance of a horizontal slide. It is not, therefore, always possible, especially in the absence of underground workings, to determine the exact direction of the movements which have accompanied a fault.

assume that similar effects have been produced by similar causes acting within a very limited region. And, if this hypothesis be admitted, we can advance a step further, and point to the probable origin of these great diverging fissures: for the valleys start from a central region, which is violently broken, where the dip and range of the stratified masses is unsymmetrical, and which is marked by protruding mountains of granite and syenite.

Secondly. Notwithstanding the great dislocations of the masses of green slate and porphyry, forming the support of the limestone, there is hardly any instance in which they are bent and contorted. After seeing the violent contortions of some portions of the other slate systems of the region, this fact might appear inexplicable; but we find a solution of our difficulty in the enormous irregular masses of hard unbending felspathic and porphyritic rocks, imbedded in, and so intimately mixed with, the green quartzose slate, that we in vain seek to separate the formations from each other. If, then, we admit the igneous origin of the porphyries, in what way can we account for the accompanying, and apparently almost contemporaneous, deposits of stratified chloritic slate? I know no explanation so probable as that which supposes igneous and aqueous causes to have acted together—the porphyries to have been produced by some modification of submarine igneous action—and the chloritic slates to have been deposited from the waters in the same region, and in the same periods of time: the first operation supplying, at least in part, the materials for the second, and similar operations being many times repeated.

Thirdly. The previous details enable us clearly to determine the mean line of bearing of the whole system of stratified rocks associated with the limestone; and this line makes the schistose masses, one after the other, to abut against the carboniferous zone. This fact alone proves that the older and newer systems are entirely unconformable—a conclusion confirmed by all the sections which connect the slate rocks with the calcareous zone.

Again: There is no gradation between the two systems; their position is not only unconformable, but the transition from one system to the other is instantaneous. Masses of red conglomerate are found here and there, near the base of the older mountains, resting upon the edges, and filling up the inequalities of the component strata, and upon these conglomerates are deposited the lower beds of the carboniferous limestone. These facts seem to prove, that the elevation of the cluster of mountains of Cumberland was sudden (which seems to be almost implied by the great faults and dislocations above described, as well as by the regularity of the lines of bearing), and that all those causes which produced the elevation of the older strata, and deter-

mined their line of bearing, had ceased to act before the completion of the old red conglomerates.

In the region above described there is no connexion between the direction of the valleys and the mean line of bearing of the formations; and one of the means successfully used by M. Elie de Beaumont in grouping together distant mountain chains, would, in this instance, entirely fail us. I do, however, think that the leading doctrine of the Essay on the Epochs of Elevation (viz., that mountain chains elevated at the same period of time have, even when widely separated from each other, a general parallelism in the bearing of their component strata), receives a strong confirmation from the position of the older formations of the British Isles.

It is now generally allowed that the old chains of mountains, mainly composed of clay-slate and greywacké, which give so great an impress to the physical character of this island (viz., the chains of Cornwall, of North Wales, of the Isles of Man and Anglesea, of Cumberland, of Lannermuir, including the whole range from St. Abb's Head to the Mull of Galloway, &c. &c.), are nearly of the same age, and were probably all elevated before or during the period of the old red sandstone. Now if a line be drawn along the axis of the Cornish chain; a second parallel to the prevailing ranges of the higher Welsh mountains, as laid down in Mr. Greenough's map; a third in the direction of the strata of Anglesea; a fourth in the axis of the greywacké chain of the Isle of Man; and a fifth from St. Abb's Head to the Mull of Galloway; all these lines will make a near approach to parallelism with the line of bearing in the system of the Cumbrian mountains, as established by the previous details. Is this parallelism accidental? I am unwilling to believe it; and although there are even in England some remarkable exceptions to this arrangement, I think that the facts here stated afford, as far as they go, a confirmation of that principle on which are founded many of the bold generalizations of the extraordinary essay of M. Elie de Beaumont, to which I have alluded.

§ 3. *On the Great Dislocations by which the Cumbrian Mountains became separated from the Central Carboniferous Chain, &c.*

The internal movements which produced the derangement of the groups of strata described in the preceding section were succeeded by a long period of comparative repose, during which our whole carboniferous series was elaborated. Had our island been laid dry immediately after that period, without any change of relative position among the great formations, the Cumbrian mountains would have appeared as a cluster of ancient rocks rising out of a great carboniferous plain; extending north and south from the border of Scotland to

the very heart of England, and in a transverse line from the German Ocean to the Irish Sea, and as far west perhaps as the Isle of Man. The remains of the carboniferous strata in the northern and central parts of England, notwithstanding the manner in which they have been dislocated, and afterwards covered up by newer deposits, justify us in giving them this great original extent, and thus bringing them almost to the confines of the carboniferous system of the Bristol Channel.

This carboniferous period (during which we have no indications of great internal movements producing mountain masses with their strata in discordant positions), was immediately succeeded by some of the most remarkable convulsions which have affected our island. During these convulsions, took place some of those extraordinary dislocations of the coal measures on the confines of the Bristol Channel (so admirably described in former memoirs read before this Society*), and also the elevation of the great northern central chain, extending from the neighbourhood of Derby to the mouth of the Tweed: and during the same period the calcareous zone surrounding the Cumbrian mountains was torn off from that part of the great northern chain, which, after deflecting a little to the north-west, is prolonged through the crests of Cross Fell to the confines of Scotland.

I only mention the carboniferous system of the Bristol Channel for the purpose of founding upon it one or two general remarks, and of contrasting it with the northern chain of the same period.

First. The axes of the different coal basins on the Bristol Channel seem to form a striking exception to the rule above quoted, viz., that regions of contemporaneous elevation are marked by parallel lines of bearing. Among the axes of these basins there is certainly no such parallelism.

Secondly. As the calcareous slates of North Devon and of a part of South Wales do not conform to the rule which appears to govern the range of the greatest number of our greywacké chains; but, on the contrary, run nearly east and west, in a direction parallel to the axis to the great elliptical coal basin of South Wales; is it not highly probable that the anomaly was caused by the extension to North Devon and a part of South Wales of the same forces which produced the actual configuration of that basin? Or, in other words, may we not conclude, that the great elevatory movements of the greywacké series of North Devon and of a part of South Wales took place after the completion of the carboniferous series; and, therefore, many ages after the

* See the sections accompanying the Memoir by Messrs. Buckland and Conybeare, Geol. Trans., New Series, vol. i. p. 210, &c.

movements which produced the strike and dip of the Cumbrian mountains as above described?

Thirdly. The form and direction of the dislocations in the coal fields on the Bristol Channel bear little resemblance to those of the northern carboniferous chain—a circumstance probably originating, partly in the local nature of the disturbing forces themselves, and partly in the fact that the application of these forces in the two carboniferous regions was not contemporaneous.

After the first elevation of the central carboniferous chain of the north, the lowest division of the new red sandstone group (*rothe-todte-liegende*) was immediately deposited. The movements of elevation were not merely followed by, but were probably the mechanical causes of, this deposit; which is composed of sand, small pebbles, and other incoherent materials, drifted to the outer and lower edges of the coal-fields; even at this day is in many places but imperfectly cemented; and contains, though rarely, a few drifted coal plants*. In some districts it is perfectly conformable to the upper coal strata on which it immediately rests, and seems to form a regular connecting link between them and the overlying formations; but, considered on the whole, its position, as far as regards the inferior strata, is discordant. It was followed, and perhaps interrupted, by movements of elevation, producing a considerable derangement in its component beds, and, of course, also affecting the lower formations; and these movements were succeeded in several parts of Yorkshire, and of the Cumbrian mountains, by deposits of magnesian conglomerate and magnesian limestone—unconformable both to the lower division of the new red sandstone (*rothe-todte-liegende*) and to the coal measures†.

Now the overlying deposits of the Bristol coal-fields are perfectly analogous to the series in the North of England, which commences with the magnesian conglomerate; but they appear to contain no representative whatsoever of the lower division of the new red sandstone. Hence we may, I think, conclude (not hypothetically, but on direct physical evidence), 1. That the movements which gave the final configuration to the coal-fields on the Bristol Channel took place after the deposition of the lower red sandstone, and were probably contemporaneous with the second system of movements in the North of England, before alluded to. 2. That the movements (prior to the existence of the lower red sandstone or *rothe-todte-liegende*) which gave the chief impress

* See Geol. Trans., Second Series, vol. iii. p. 64. Traces of vegetable fossils occur in this deposit, on the coast of Cumberland, near Whitehaven. Stems of Equiseta and other vegetable impressions have also been found in it at Hickleton in Yorkshire, by the Rev. W. Thorp of Doncaster. I was unacquainted with these facts at the time the Memoir just quoted was composed.

† See Geol. Trans., Second Series, vol. iii. Pl. VI. figs. 3. 4. 5. 6.

to the carboniferous chains of the North, took place during a time long anterior to the principal dislocations of our south-western coal-fields*.

Fourthly. Though the contortions of the carboniferous system of the Bristol Channel are so very extraordinary, the actual elevation of the beds is much less than that of the northern chain. This is perhaps the reason why the secondary rocks, from the new red sandstone to the chalk, have in their range from the south coast to the latitude of Derby, a direction nearly parallel to the mean bearing of the greywacké chains—that is, the very direction they would have had, provided they had been deposited immediately on the flanks of the greywacké chains, without the intervention of the carboniferous series. Thus, for example, the principal line of transition limestone in South Wales is nearly parallel to the direction of the great oolitic terrace in the corresponding latitudes. In making this observation (which must not be pushed too far), all minor inequalities are, of course, left out of account, as well as the changes of bearing produced by much more recent disturbing forces—such, for instance, as the great saddle of the wealds of Kent, and the east and west range of the vertical chalk through the Isle of Wight and a part of Dorsetshire.

Now if we follow the same secondary beds beyond the latitude of Derby, we find a sudden change in their direction, bringing them nearly into parallelism with the great central carboniferous chain of the North. From which it appears, that this chain was of sufficient magnitude to produce, by its elevation, a great change in the bottom of the neighbouring seas, and, consequently, to produce an immediate influence upon the direction of all the strata afterwards deposited, by the same seas, upon its flanks.

Leaving the consideration of subjects which may appear remote and hypothetical, I now proceed to describe the nature of some of the greater dislocations produced by the elevation of the northern carboniferous chain. The disturbing forces, acting with their greatest intensity in a direction nearly north and south, commenced in the latitude of Derby, and produced their first effects towards the north in elevating the High Peak limestone and the coal-fields on its eastern flank. They are marked by a system of great longitudinal faults ranging on the west side of this limestone region†.

* I am aware that this conclusion has been objected to by some of our best geologists, but I do not believe that they have personally examined the whole evidence on which it rests.

† See Pl. V. fig. 1. Some interesting phenomena connected with these faults are described in Farey's Geological and Agricultural Survey of Derbyshire. The accompanying section is not intended to convey any details of stratification, but only a general notion of the position of the great mineral masses. The toadstone beds of the High Peak limestone are intentionally omitted.

Continuing the range towards the north, the elevatory forces seem to have operated more feebly, as the limestone is not brought up to the surface. But their line of action is, in some places, marked by an irregular saddle of millstone grit, forming the water-shed between our eastern and western coasts. The great saddle of millstone grit at Blackstone Edge, flanked by the Lancashire and Yorkshire coal-fields, is a good example of this arrangement*.

A few miles further towards the north the mountain limestone is again protruded: the chain gradually arises to a commanding elevation, and is continued as far as Stainmoor, preserving throughout a great similarity in its external forms, and an almost perfect identity in its internal structure.

Near that part of this range where the carboniferous mountains begin to present a decided escarpment towards the west, commences a great longitudinal fault (or perhaps a system of faults), which has been traced by Mr. Phillips from the heart of Craven to the hills near Kirkby Lonsdale, and excellently described in a paper published in a former volume of our Transactions†. I must refer to this paper for the proof that the great Craven fault has rent asunder a part of the carboniferous chain, and produced such a downcast on the west side, that mountain masses of limestone are tumbled into the neighbouring regions with an inverted dip; and that a coal-field which ought to appear above the top of Ingleborough, has sunk below the level of its base‡.

From beneath this coal-field the limestone beds again rise up, and after passing in the form of a great arch over Farlton Knot, recover their horizontal position, and are prolonged into those tabular hills mentioned above, which form the south-western skirt of the Cumbrian mountains. From which it appears, that the southern calcareous zone of the Cumbrian system, is cut off from the central chain by the intervention of the great Craven *fault*.

I once imagined that this great *fault* ranged through the neighbourhood of Kirkby Lonsdale and Farlton Knot, and there terminated. It is unquestionable that lines of dislocation do range in the direction here indicated (as is proved by the position of the limestone of Kirkby Lonsdale bridge, and the still more remarkable position of the limestone between Casterton and Barbon); but after several subsequent visits to the neighbourhood, I found that the leading branch of the Craven *fault* ranged along the line of junction of the central chain with the skirts of the Cumbrian system, passing along the south flank of Casterton Low Fell, up Barbondale, thence across the valley of Dent, through the upper part of the valley of Sedbergh, and along the flanks

* See Pl. V. fig. 2.

† See Geol. Trans., Second Series, vol. iii. p. 5—15.

‡ See Pl. V. fig. 3.

of Bawfell and Wildboar Fell, to the ridge between Mollerstang and Ravenstone dale; and that along the whole of this line there are enormous and most complex dislocations. Some of these phenomena I hope to describe more at length in a future communication; and for the present I only observe, that a great upheaving force acting at once upon the two contiguous and unconformable systems, produced a great strain and separation of parts, accompanied with fractures and dislocations, principally along the line of their junction*.

In a part of the range between Mollerstang and Ravenstonedale the cluster of the older mountains, by deflecting to the north-west, quits the central carboniferous chain; and it becomes a question of some consequence to determine the further range and nature of the great Craven fault. The ruptures produced by it are fortunately on a scale too great to be overlooked or misunderstood. It ranges through Mollerstang into the hills immediately south-east of Kirkby Stephen, and thence skirting the escarpments which trend towards Stainmoor, finally stops near the foot of the mountain-pass. Its progress is marked by a lofty ridge of carboniferous limestone, which has been upheaved from the very base of the whole system, contorted and shattered, and then sent headlong into the valley, where it is to be seen on edge for many miles; and where its lower extremities lie buried under accumulations of alluvial matter and the horizontal conglomerates of the new red sandstone†.

In following these dislocated ridges in the opposite direction, we may trace them into the calcareous hills of Ravenstone dale, where they expand themselves and assume a more horizontal position, and in this way gradually pass into the unbroken calcareous zone which skirts the north side of the Cumbrian mountains as far as Egremont. Thus, it appears that the northern and southern calcareous zones of the Cumbrian mountains are cut off from the central chain by the same *fault*, which, both in the neighbourhood of Ingleton and Kirkby Stephen, has produced a great downcast on the western side of its range‡.

So far it appears that we have a clear and consistent explanation of the re-

* See Pl. V. figs. 4. 5.

† See the southern extremity of the section, Pl. V. fig. 7.

‡ See Pl. V. figs. 3. 7. The effects produced along the line of dislocation on the lower beds of the carboniferous system vary with the circumstances of the case. Where the beds abut against the steep sides of the greywacké chain, their broken ends have undergone a movement of elevation. Under such circumstances a depression like that at Ingleton, or the still more complex derangement of the strata, like that in the valley above Kirkby Stephen, was obviously impossible. See Pl. V. figs. 4. 5. These two figures are ideal; the former being intended to represent the undisturbed, and the latter the disturbed, position of the greywacké and carboniferous series.

lations of the central carboniferous chain to the secondary zones of the great cluster of the Cumbrian mountains. But there is still one difficulty to be explained. Beyond Stainmoor, the western border of the central chain deflects, as before stated, considerably towards the north-west, and rises into an escarpment, partly made up of mural precipices, which overlooks the plain of the new red sandstone in the vale of the Eden, and in the crest of Cross Fell reaches the elevation of 2900 feet. On the contrary, the northern calcareous zone of the Cumbrian system dips under the plain of the new red sandstone, and along the course of the Eden, lies buried probably many hundred feet below the surface. This relative position is explained in a transverse section from the central mountains to the ridge of Cross Fell: and it seems impossible to account for the collocation of the two carboniferous systems without the intervention of a *fault* ranging somewhere near the base of the chain of Cross Fell, and producing an enormous upcast to the north-east*. The misapprehension of this *fault* formerly introduced a great error into certain published sections, in which the new red sandstone of the Eden was placed *under* the whole system of Cross Fell†.

Fortunately in this, as in the former case, we have better evidence than a mere inference; for in following the escarpment from any portion of the Cross Fell chain to the foot of Stainmoor (the key of the whole position), we have a manifestation of the true nature of the *fault*, and on a scale hardly to be rivalled in any other part of our island‡. A little before we reach Brough, there commences a steep craggy mountain ridge, ranging parallel to the principal escarpment; from which it is separated by a ravine several hundred feet in depth. On entering this ravine, we find ourselves on the very line of an ancient convulsion, by which the whole craggy ridge has been torn off from the escarpment, and tumbled over into the valley, in which it now stands on edge; every part of it being inclined at a very great angle. It is of vast thickness, and probably includes nearly the whole calcareous system of Cross Fell: but its upper beds are buried under the alluvion of the new red sandstone.

These inclined beds (on a part of which stands the town of Brough) are prolonged to the foot of Stainmoor, and thus brought into contact with the dislocated beds thrown down from the opposite side of the valley by the great

* See Pl. V. fig. 6.

† See a paper by Professor Buckland (Geol. Trans., First Series, vol. iv. p. 105), in which this mistake is rectified.

‡ There are some other places near the base of the carboniferous chain where we meet with indications of the nature of the Cross Fell fault. (See Geol. Trans., First Series, vol. iv. Pl. V. figs. 2 and 3.) But in none of them is the evidence comparable to that exhibited in the Brough section.

Craven fault. The transverse section from the hills above Brough to the hills above Kirkby Stephen, shows the singular relations of these dislocated masses*.

It thus appears, that during the elevation of the central carboniferous chain of the North, there were great changes of level among the component strata,—and that the points of greatest stress not being upon the same straight line, the fractures were sometimes inclined to each other—that the great Craven *fault* and the great Cross Fell *fault*, intersecting each other at a considerable angle near the centre of the chain, shattered and cut off from it a great triangular mass of the component strata—and that this triangular mass, being thus cut off by the disruptive forces of elevation, underwent a change in its relative level, and was at the same moment affected by a great downcast movement; of which we have a most convincing proof in the present extraordinary position of the mineral masses at the foot of Stainmoor, and on the line of section.

I am far from supposing that in the preceding details I have pointed out all the great movements whereby our northern mountain chains have been affected. All I have attempted to do has been to explain the nature of certain great dislocations of which we have direct evidence, and of which we can determine the geological epoch; and thence to show the general effects they have produced on certain mountain groups in the North of England.

If I wished to speculate on the causes of these great movements among the integuments of the mountains, I should point to the porphyries of the Cheviots and the syenite of Charnwood Forest, rising at the two extremities of the carboniferous chain. I should also point to the granitoid rocks near Dufton Pike; and perhaps also to the Whin Sill, and the other masses of augitic trap, associated so largely with the calcareous system of Cross Fell†.

If it were objected, that the porphyry of the Cheviots sometimes resembles the old felspathic rocks of Cumberland, and sometimes passes into syenite and granite; and further that we have proofs of its existence before the conglomerates of the old red sandstone: we might on the other hand reply, that such facts throw no difficulties in the way of supposing, that the Cheviot porphyry (like some of the other crystalline formations of Scotland), was elevated *en masse* at some period subsequent to its first formation; especially as we can show, to the north of the Tweed, derangements exactly answering to such an elevation. We might further reply, that the red porphyries of the Scotch Border, however like each other in mineral structure, are not all of the same

* See Pl. V. fig. 7. † See Geol. Trans., First Series, vol. iv. p. 109, &c.

age; inasmuch as some of them are unequivocally posterior to a portion of the coal measures. The discussion of these subjects would, however, lead me too far from the direct object of this paper*.

Many of the great movements above described, appear to have been produced by an action both violent and of short duration. The nature of the fractures leads us to this conclusion, as well as the nature of the mineral masses resting immediately upon the dislocated beds. In some portions of our coal-fields there may be indications of a passage into the next superior order of formations. But in the neighbourhood of the great faults above described, there is certainly no such indication, or anything whatever which could mark the slow progress from one system of things to the other.

That these great fractures were produced by some modification of volcanic action is, to say the least of it, a very probable hypothesis. But, granting this hypothesis, what proper measure can we set up for the intensity of volcanic power during any one geological period of the earth, except that which is defined by the effects produced? Guided by this rule we assume nothing: and though we fall into error from hasty generalizations, our conclusions, unfettered by theory, are ever open to correction; and as observations are multiplied, gradually approximate nearer and nearer to the truth.

Of the cause of volcanic action we know nothing; but we know enough of

* At Rodham, a few miles from Wooler, the carboniferous series is separated from the Cheviot porphyry by an old red conglomerate forming the base of the stratified rocks. The conglomerate contains many pebbles identical in structure with the porphyry, which must therefore have existed *before* the carboniferous series: and the conclusion is confirmed by similar phenomena in Roxburghshire. Judging, however, from the inclination of the stratified masses, we should, I think, be led to infer, that the porphyry had undergone some movement since their deposition.

A porphyry perfectly identical with that of the Cheviots, in the same range, and sometimes passing into a true granite, breaks out in Lamberton Hills, a few miles north of Berwick; and near Shiels runs down close to the coast. At this point the red sandstone (subordinate to the old carboniferons formation of the Tweed), which forms the sea cliff, suddenly becomes vertical, and in some places is moved more than 90° from its undisturbed position. The phenomena are correctly described in a paper published by Mr. Witham in the Newcastle Transactions: but the important fact of the close approach of the granitoid porphyry appears to have escaped his notice. It seems to prove, unequivocally, that the Lamberton porphyry assumed its present position *after* the epoch of the carboniferous system of the Tweed. I mention these apparently contradictory facts for the purpose of showing, how difficult it is to prove the age of igneous rocks by any single set of phenomena.

Trappean rocks are very abundant in the higher parts of the Tweed, and have a great similarity of mineral structure; yet it is generally impossible to come to any certain conclusion respecting their epoch. At Cowdenknows (a few miles north-east of Melrose), a red porphyry distinctly overlies a red sandstone similar to that in the lower course of the river.

the effects of this action to be certain, that it cannot be ever brought under the mechanical laws of any constant force. To assume therefore, independently of an incomparably wider induction from facts than has yet been made, that *volcanic forces have acted on the earth during all geological periods with equal intensity,* is so far from being sound philosophy, that it is a mere gratuitous assumption—founded, it may be, upon a mistaken analogy between the calculated effects of constant forces, and the effects of other forces, which are not only not constant, but which are unknown in their origin and undefined in their power.

Judging from facts alone, and independently of all hypothesis, I adopt some of the leading principles of the Essay on the Epochs of Elevation by M. Elie de Beaumont, to which I before referred. They are certainly open to numerous exceptions; especially in low geological regions like many of those in our Island. But among mountain chains which are well defined and of considerable elevation, they are, I believe, of very extensive application and of unquestionable importance. The two systems of dislocations, described in the second and third sections of this paper, mark two epochs of elevation which have had a great effect in modifying the structure of this Island.

Note.—I hope I may be excused in very briefly anticipating some of the conclusions which seem to follow from a detailed examination of the Cumbrian mountains.

1. The crystalline structure of some of the slates appears to have been superinduced after their deposit by an action from below. This seems to be certain, as far as regards a zone of indurated slates which surrounds the boss of Shap granite; and it is at least a probable explanation of the crystalline structure of the lowest group of slate rocks in Skiddaw Forest.

2. There are, in many large tracts of the Cumbrian system, slate beds with a decided transverse cleavage, alternating with coarse flagstone and greywacké, and not associated with any igneous or unstratified rocks. Similar facts are repeated in North and South Wales on a more extended scale, where the slates sometimes pass into true chlorite slate, alternating with other unaltered slaty masses. In such cases we have no right to assume that the crystalline structure has been produced by any modification of igneous action. Hence it appears to be a rash generalization to attribute the crystalline structure of *all* primary slate rocks to direct igneous action. This negative conclusion is further confirmed when we consider that secondary deposits, by the mere chemical action of their particles, unaided by any igneous cause, sometimes assume a perfectly crystalline structure. For example; many beds of moun-

tain limestone are perfectly crystalline;—and the large globular structure of magnesian limestone has occasionally been superinduced on masses originally deposited in thin laminæ; as is demonstrated by the fact, that the lines of the original laminæ may still, in some instances, be traced through a congeries of balls mutually compressing each other. These peculiarities of structure are found in places where there is not the least indication of any igneous action.

3. The highest greywacké group of the Cumbrian mountains contains beds with numerous organic remains. The next inferior group (composed of green slate and porphyry), and the third group in the descending order (composed of fine, black clay slate and greywacké slate, &c.), contain no organic remains. How can we account for the absence of organic remains in this third group, except on the supposition that they did not exist in the seas where it was deposited? It is developed through large mountain tracts, and is, with very few exceptions, composed of rocks unaltered by igneous action. Had there been any organic beings where it was deposited, we should, I think, have found their remains imbedded in it. We arrive at precisely the same conclusions in traversing the whole slate system of Devonshire and Cornwall. The upper part contains organic remains; the lower part does not. Yet in the *lower part* there are large tracts where the rocks are unaltered, and contain beds of limestone and calcareous slate, not more crystalline than ordinary beds of mountain limestone. The same positive and negative conclusions are strengthened by the phenomena of North and South Wales. I may state generally, as the result of my own observations on the older strata of this Island, that there is a line in the descending series where organic remains seem entirely to disappear; and that this line is by no means coordinate with mineral changes superinduced by igneous action. It is true that igneous action has in many cases produced a crystalline structure in stratified masses, and obliterated their organic remains: but it is not by any means true that this action *always* accounts for the absence of organic remains from the older strata.

4. The ancient separation of the old schistose deposits into two great groups (the upper containing organic remains, and the lower not,) appears, therefore, to be borne out by the phenomena of our Island. This separation is, however, on two accounts, of very little importance. *First*, Because the two groups almost entirely interchange mineralogical characters. *Secondly*, Because, between the two extremes, there appears to be an enormous development of rocks, in which organic remains (though appearing here and there) are very rare. Hence it must always be difficult, and oftentimes impossible, to draw any precise line between the two groups in question.

5. I believe, however, that there is a broad mineralogical distinction between the primary stratified rocks (including under that term all stratified rocks inferior to the old red sandstone,) and the secondary,—and a still broader,

between the primary stratified groups and the deposits superior to the chalk. In some instances secondary rocks have put on the exact appearance of the primary: but is there a tertiary deposit in any country yet examined, which could for a moment be confounded with the greywacké systems of Cumberland or Devonshire? Through large regions of the earth, the epoch of many deposits is not less defined by the mineral structure of the rocks than by their organic contents. Accurate mineralogical distinctions, and an order of superposition determined by natural sections, must form the first foundations of the geology of every country. Organic remains often help us to unite together disconnected base lines. They also enable us to subdivide the successive deposits of one epoch, in cases where all other means fail; and in speculating on the former conditions of the earth they are invaluable: but they can in no instance supersede the necessity of studying in detail the structure and superposition of the great mineral masses composing the crust of the globe.

6. In the Cumbrian system, the elevation of the old slate rocks appears to have been produced by the protrusion of mountain masses of granite and syenite. In the higher parts of North Wales, the strata are thrown into vast undulations ranging parallel to the principal mountain chain; but we find no obvious centre of dislocation. This fact however throws no difficulty in the way of the igneous hypothesis of elevation; as we know that the most violent volcanic action is often felt at a great distance from the focus of eruption. The parallelism of the undulations seems however to prove, that they were not produced by different shocks of earthquakes succeeding each other after long intervals of time.

As the earth has apparently diminished in temperature, we have a right to look for some indication of a contraction of its dimensions. May not some of the great parallel corrugations of the older systems of strata have been produced by such a partial contraction?

7. In stating that volcanic action could not be brought under the laws of any constant force, I merely made a reference to the irregular and undefined nature of its effects. The degradation of the solid portions of the earth by aqueous action may in a certain sense be considered constant; because there is a demonstrable provision in the laws of nature for the perpetual circulation of water over the surface of the globe. But who can point out, compatibly with the known laws of chemical action, a provision for the eternal and uniform circulation of volcanic fire through all parts of the crust of the globe—to go its rounds with regularity, and, during given periods of time, neither to increase or diminish in intensity? If such a supposition be started, it can only be regarded as a mere gratuitous and most complicated hypothesis; and ought not ever to be assumed as the basis of *à priori* reasoning.

Every case of volcanic combustion *may* be only an instance of chemical combination on a great scale; in which case, after it ceases, the particles acted on are held together by new affinities more powerful than those which existed among them before, and are in a new condition of chemical equilibrium. Each successive instance of volcanic action must bring the crust of the earth nearer and nearer to a state of ultimate chemical quiescence: volcanic fires like all other fires must exhaust themselves; and must cease entirely, when the whole crust of the earth has reached its highest state of oxidation, or when the solid parts are in that state of combination which represents the highest order of chemical affinities compatible with the physical constitution of the earth. Whether the earth is ever actually to reach that state, is a question not affecting the hypothesis, and, of course, admits of no reply.

Or we may argue on another hypothesis—that volcanic action is produced by the penetration of water through the surface of the earth, to a liquid mass of highly heated matter far below. Even in this case there must be *some chemical action*: for we know that unoxidized bodies are always present; and if these produce some influence on volcanic products, they must also produce some influence, however small, on the intensity of volcanic force. Let us, however, exclude the effect of chemical action altogether; still, volcanic action must diminish in frequency and intensity, during the evolution of the successive geological periods, by the mere refrigeration of the earth (a fact implied in the terms of the hypothesis), and by the greater difficulties offered to the penetration of water through the parts which have gradually become solid.

Perhaps, however, it is best to exclude all hypotheses, and to acknowledge our entire ignorance of the cause of volcanic action. In that case we have no right to assume, that it either is, or is not, of the nature of a constant force. To assume either the one side of the question or the other is perfectly gratuitous; as it can only be decided by induction from the geological phenomena of every known epoch.

As a matter of observation, modern volcanic forces appear to have modified the earth in two ways. First, by violent paroxysms, splitting up the crust of the earth, and producing lines of volcanic vent (such as those described in the works of Humboldt and Von Buch), generally of small curvature, and extending through great geographical regions. Secondly, by local action on the great lines of vent, producing all the ordinary phenomena of volcanic cones and eruptions of lava. To the former kind of action, the forces which have produced the elevation of some of our mountain chains appear to have been most nearly assimilated.

Walton, May 1833.

Appendix to Professor SEDGWICK's *Paper entitled "An Introduction to the General Structure of the Cumbrian Mountains."*

[Read November 6, 1833.]

IN the preceding paper, p. 49 *et seq.*, describing in detail the range of a band of limestone and calcareous slate separating the upper from the middle division of the schistose rocks of the Cumbrian mountains, I have mentioned two great faults, between Coniston-water Head and Windermere; one throwing the calcareous beds to the south, and the other to the north, of their line of bearing. Both these faults are of enormous magnitude, and the calcareous slate between them, ranging about 40° north of true east, past two or three small mountain tarns, terminates in some broken masses, just where a cross road strikes off from the Ambleside turnpike to Skelwith bridge; being there cut off by the most northern of the two great faults above mentioned. This part of the range is about a mile and a half in extent; and the calcareous bands, commencing in a low hill north-east of Coniston Hall, exhibit some dislocations which, although of comparatively small extent, deserve notice.

About one third of a mile from their commencement, the calcareous bands are cut through by a fault, throwing them fifty or sixty feet towards the south-east. The line of dislocation is marked by a small watercourse, and by some masses of calcareous slate thrown out of their bearing. The beds then regain their strike (about 15° north of magnetic east), and run to a round hill, due south of the lowest tarn. There they are again cut off, and shifted about 150 or 200 yards, to a point south-east of the tarns. Thence they range (nearly with the same strike as before) uninterruptedly for more than half a mile; increasing, however, gradually in dip as they approach a mountain mass of green slate and porphyry, called Pool Brow. Immediately beyond a mountain road leading to Arnside, there is a third dislocation, throwing the beds about 120 paces to the south-east. Beyond this interruption the limestone is again continued, but is soon after (in consequence, I believe, of a number of small dislocations), spread over the brow of a hill (*Limestone Hill*), and descends to the angle of the Skelwith bridge road, the extreme point being marked by a kiln on the Knipe Fold estate. Here the limestone bands are again cut off, being thrown (as stated in p. 52) more than a mile to the north of their bearing.

Such details as these may be considered of small importance, but they belong to the history of the formation I am describing. There are, however, other phænomena of more importance, and extremely well exhibited along the line just described. The calcareous slates sometimes pass into strong beds of limestone: but without exception they exhibit true cleavage planes, which often almost obliterate the lines of stratification; and the calcareous beds (even where they pass into a pure subcrystalline limestone), when struck with the hammer, break into tabular masses, having their faces parallel to the cleavage of the slates. These calcareous beds abound with Corals, Bivalves, Trilobites, &c., and have a south-easterly dip, varying from 30° to 60°. The planes of cleavage generally dip toward the north-west, at a great angle. They sometimes *strike* with the beds, and sometimes cut obliquely through them; but I could not find any instance where the planes of cleavage and the true beds coincided.

I stated (in the paper before mentioned, p. 54) that the calcareous bands were cut off by the Shap granite, and the assertion was, I believe, true: but during the past summer I ascertained that these bands reappear, in their line of strike, on the north side of the granite boss, in the new road cut through the morass, from Shap Wells to the turnpike leading to the village of Shap. The same calcareous bands appear also in the rivulet, about a quarter of a mile north of the wells, nearly with the strike and dip above mentioned, and so pass under the horizontal beds of the old red sandstone and conglomerates which form the base of the mountain limestone ridges, stretching out on the north side of the district. It deserves remark, that the calcareous slates are broken through by porphyritic masses, but reappear in the form of calcareous conglomerates imbedded in the greywacké. These conglomerates are impregnated with pyrites, and give rise to the mineral waters of Shap Wells.

It appears, therefore, probable, from what has been already stated, that the Shap granite interrupts the continuity of the calcareous bands, and is therefore of an origin posterior to them. The same truth is rendered probable by the extreme induration of the upper greywacké series, where it approaches the granite. The conclusion is, however, put out of all doubt by a fact I observed for the first time, this summer; viz. that near the farm-house called Wasdale Head, the granite is in two places seen to send veins into the greywacké; which near its contact with the granite passes into a rock, very much resembling the more crystalline varieties of the Cornish killas. These phænomena, taking place among the upper fossiliferous divisions of the slate series, are of considerable theoretical importance; but I shall not dwell upon them, as I shall have to return to the subject in a subsequent paper.

III.—*Description of a Series of Longitudinal and Transverse Sections through a Portion of the Carboniferous Chain between Penigent and Kirkby Stephen.*

By the Rev. ADAM SEDGWICK, V.P.G.S. F.R.S. &c.

(woodwardian professor in the university of cambridge.)

[Read March 2 and 16, 1831.]

§ 1. *Introduction.*

HAVING in the preceding communication pointed out some peculiarities in the position of the great central carboniferous chain (which extends from the neighbourhood of Derby to the Scotch Border), with the view of connecting it with the calcareous zone of the Cumbrian mountains; I now proceed to describe in detail the composition of a very remarkable portion of it, forming a mineralogical link between the High Peak of Derbyshire and the region of Cross Fell. The facts adduced will serve to explain some of the changes the chain undergoes in its range between one extremity and the other; and will also supersede the necessity of many details respecting the carboniferous zone of the Cumbrian mountains, which once formed, beyond doubt, a continuous part of the same system, and is now only separated from it by the great breaks and dislocations described in the preceding paper.

The principal section* about to be described, commences at Penigent in Horton parish, and, passing through the highest mountains of the range, ends in the plain of Kirkby Stephen. Two other sections† connect this line with the ridge of mountains on the west side of Swaledale. Nearly at right angles to the same line are drawn a series of transverse sections‡, prolonged across the breaks connected with the great Craven *fault*. They will, I hope, place in a striking point of view some of the internal movements which took place when the chain was elevated, just before the period of the new red sandstone.

The old red conglomerates do not appear in any part of the longitudinal section, but they are exposed in one of the transverse sections§, and are seen

* See Plate VI. fig. 2. † Fig. 3. and 4. ‡ Fig. 5. 6. 7. 8. and 9. § Fig. 8.

in several other places, at the junction of the carboniferous chain with the unconformable greywacké mountains of Westmoreland. There can, therefore, be no doubt that the lowest beds of the carboniferous system of this region rest upon an irregular surface of unconformable greywacké slate, from which they are separated, here and there, by great irregular masses of old red conglomerate.

The whole overlying series is essentially composed of alternating masses of limestone, sandstone, and carbonaceous shale, terminating in a great system of beds connected with the millstone grit. The limestone groups are incomparably the most continuous and the best defined, and form a kind of framework by which all the other component parts are held together. They are six in number, and will be referred to in the several sections, under the following names:—1st, *Great scar limestone.* 2nd, *Black marble limestone.* 3rd, *Strong post limestone.* 4th, *Wold* or *Mosdale Moor limestone.* 5th, *Four-fathom limestone.* 6th, *Main,* or *twelve-fathom limestone.* The names given to the 1st, 5th, and 6th groups are in common use in the North of England, and on that account ought not to be changed. The other three groups might be conveniently designated in the section by the names 2nd, 3rd, and 4th limestones: but these names would cease to have any propriety if applied to remote parts of the same chain, and therefore ought not to be made use of, except in local description.

To prevent a frequent repetition of nearly similar details, I shall commence with an enumeration and description, in the ascending order, of all the remarkable groups of strata which appear upon different parts of the lines of section.

§ 2. *General Section of the whole System, in the ascending order*.*

1. *Great Scar Limestone.* Total thickness about 600† feet.—The term *scar,* in the dialects of the North, means any bare precipice on the face of a mountain, and is applied with great propriety to this limestone, which in all parts of its range is marked by grey precipices and mural escarpments. The grey scars near the base of Ingleborough, of Penigent, and of Whernside; the mural precipices above Giggleswick and Malham, and the magnificent cavernous gorge of Gordale, are among the striking exhibitions of this deposit, and present a nearly exact counterpart to the features of the same limestone in the High Peak of Derbyshire.

* See Pl. VI. fig. 1.

† This number is merely approximate, and there are only a few places where the whole thickness is visible. It is probably very variable, as the deposit has taken place upon an uneven, unconformable surface.

Like the Peak limestone, the group, here described, is full of fissures and clefts (often of unknown depth), in which the mountain torrents are engulfed; and, after running in subterranean channels, and uniting with the waters of other sources, emerge in copious streams in the lower regions of the neighbouring valleys. But of all the phænomena connected with the drainage of the waters through the scar limestone, the beautiful reciprocating well above Giggleswick is the most remarkable, and even to this may be found a counterpart among the limestone hills of Derbyshire.

It contains, like the limestone of the Peak, many caverns of considerable extent; some partly open to the surface, others only to be approached through a narrow horizontal entrance. In some of these great subterranean recesses we find waterfalls of no common grandeur; in others we see no waters, but we hear them roaring among the inaccessible chambers of the rock. As a general rule, these caverns have perpendicular walls, and often nearly flat roofs. However greatly modified, they have, therefore, not been formed by the mere long-continued erosion of the waters passing through them. When the conformation is such as I have pointed out, the opposite walls are portions of the same stratum, and the flat roof is composed of the superincumbent stratum; and the cavern has the exact appearance of having been formed by one of the beds sliding off horizontally from the side of a vertical joint. I do not think such a movement impossible. The component strata, when first lifted up, were perhaps in a very unequal state of solidification, so that one part would offer a greater resistance in any given direction than another. The points of greatest stress might also be very unequally diffused; and, in consequence, the strata may have started among themselves, and undergone considerable relative movements, not unlike those we may observe among the timbers of a ship which has been wrecked, and thrown violently on her beam ends. In this way some caverns may have been formed by the sliding of solid beds upon each other, some by the gradual removal of incoherent or imperfectly solidified portions of the rock, and others by both causes combined. The subject is one of considerable difficulty, and I wish to exclude no agent from its proper share in producing the existing appearances. All I contend for is, that in such cases as I have alluded to, the slow erosion of the waters flowing through the interior chambers of the *scar limestone* is not the kind of action by which its great caverns have been scooped out.

The mineral characters of the *scar limestone* are too well known to be detailed at any length. The great bottom shales found in so many parts of England are almost entirely wanting in the line of section, and in the neighbouring country. Perhaps they are represented, in a very obscure form, by some dark-coloured beds of impure limestone, separated by bands of shale,

which occur here and there at the base of the series. In the same position are rarely found some dark and nearly compact beds, resembling the black marble series, but unfit for use; and in the prolongation of the longitudinal section towards the north (for example, near Ravenstonedale and Kirkby Stephen), beds of reddish sandstone alternate with the lower portion of the *scar limestone*, and the whole group begins to approximate to the type of the Cross Fell chain*.

There are no bands of coal subordinate to the limestone on the sectional lines; but carbonaceous and bituminous matter are the colouring principle of all the darker beds. In some instances this colouring matter is so unequally diffused, that after a recent fracture, or on a polished surface, it appears in the form of dark cloudy blotches upon a light grey base. It is this arrangement of colours, arising out of the irregular diffusion of the bituminous matter, which constitutes the beauty of some marbles in the North of England†. Near the line of section, however, no beds appear in this limestone which are fit for polishing, and very few indeed which are well suited to the commonest domestic architecture. In general they have an irregular fissured or shaken texture, which unfits them for such uses. It is, perhaps, hardly necessary to add—that their prevailing colours are light grey or bluish grey, from which they change, through every variety of shade, into dark blue, or bluish black —that their mineral characters are such as link them to transition limestone —and that they contain in great abundance corallines, encrinites, and all the ordinary well-known fossils of the carboniferous limestone‡.

The highest beds of this group often become impure, and, for about thirty or forty feet, alternate with beds of sandstone and calcareous shale; in this way forming a gradual passage into the next superior group.

2. *Group of Sandstone and Shale.* Greatest thickness 150 feet.

The thickness of this group is extremely variable, being in some places not more than twenty or thirty feet: but when it is best developed, it appears to admit of the following subdivisions:—

(*a*.) Dark-coloured shale, with nodules of clay iron-stone.

* In various parts of the North of England, where the bottom beds of the *scar limestone* rest immediately upon greywacké, they contain rolled pebbles of the inferior rock, and occasionally pass into a coarse conglomerate form. (See Geol. Trans., Second Series, vol. iii. p. 10, &c. &c.) This structure seems to have originated in the last feeble efforts of those causes which in other places produced the great masses of old red conglomerate.

† The Beetham Fell marble, near Milnthorpe in Westmoreland, is the most remarkable instance of this kind, and it is subordinate to the great *scar limestone*.

‡ Some of the rare corallines, described by the late Mr. Parkinson, were collected from localities near the line of section. See "Organic Remains," vol. ii. Pl. VI. fig. 9. &c. &c.

(*b.*) Alternations of sandy, micaceous shale, and brown, micaceous sandstone, generally of a coarse, flaggy, or slaty structure.

(*c.*) Strong beds of hard, micaceous gritstone, alternating with similar masses of slaty texture, and generally surmounted by a few beds of meagre, sandy shale.

Wherever the shale beds abound, the thickness of the whole group is extremely variable. The micaceous flagstones of the middle portion are sometimes wanting, and the group is then composed of carbonaceous shale, ironstone, and gritstone. One of the finest exhibitions of this group is at the waterfall of Hardraw Scar near Hawes. It is also well exposed by the many torrents which descend from the mountains on both sides of the valley of Dent.

3. *Second Limestone, or Black Marble Group.* Greatest thickness about 45 feet; average thickness about 30 feet.

This group is distinguished from all the rest by the regularity of its stratification, which often makes it look, on the face of a precipice, like a rude work of masonry; also by its dark-coloured, compact beds with a conchoidal fracture*. Some of these beds take a beautiful polish; and when they can be raised in large slabs free from white spots, and without seams or cross joints, are of considerable value. Unfortunately many of the quarries are almost spoilt by the cracks and fissures which traverse all the component strata: and many of the more solid masses are injured by the imbedded organic remains (such as Encrinites, Caryophylliæ, Productæ, Spirifers, &c. &c.), replaced by pure white carbonate of lime containing little of the carbon and bitumen which form the dark colouring matter of the rock.

The thin bands of bituminous shale, separating these limestone beds, also contain organic remains; and, among the rest, innumerable specimens of the *Producta latissima* and *P. Scotica*, which may be almost considered as characteristic of this group.

Nearly all the quarries, in the neighbourhood of the lines of section, from which the black marble has been exported, are found in the valley of Dent. I have however traced them, in the exact position here indicated, through Horton parish, on both sides of Chapel le Dale, in Kingsdale, and in Garsdale. They may be also traced through a part of Wensleydale, and appear at the top of the precipice of Hardraw, over which tumble the waters of a mountain torrent, forming one of the grandest waterfalls in the North of England. They are there however so much changed in structure, that they

* Most of the beds before polishing have a bluish tinge, and their weathered surfaces are of a greyish colour. On being burnt, they are reduced to a beautiful white calx, all the colouring bituminous matter being driven off.

are only identified by their relation to the other groups, and by beds of the *Producta latissima* and *P. Scotica* which follow them.

4. *Group of Sandstone, Shale, and Calcareous Grit, &c.* Maximum thickness 150 feet; average thickness about 60 or 70 feet.

The arrangement of the subordinate parts of this group is extremely variable, as the different masses frequently seem to replace each other. In an approximate way the group may be subdivided as follows.

(*a.*) Dark-coloured shale, with one or two bands of *crow-limestone* or *calliard.*

(*b.*) Hard beds of brownish, siliceous grit, generally of a somewhat slaty texture; containing subordinate, strong, hard beds of a calciferous grit, sometimes ferruginous.

(*c.*) Alternating bands of hard, brown, flaggy grit and shale.

The beds of calciferous grit are extremely characteristic of this group, and are sometimes so expanded as to form a prominent part of it. Within they are of a greyish colour; but their weathered surfaces are generally brown, from the presence of iron. The quantity of calcareous matter contained in them is very variable, as they pass at one extreme into pure, close-grained, siliceous grit; and at the other, where organic remains are abundant (which is however rarely the case), into a nearly pure limestone.

The *crow-limestone* or *calliard* is not so characteristic, as it is, here and there, subordinate to all the great masses which alternate with the six groups of limestone. It may however be proper to explain these synonymous provincial terms, as they will be frequently used in the following details. They are applied to a very impure variety of shelly limestone which is sometimes associated with gritstone, and then passes irregularly into calciferous grit, but most frequently is subordinate to the beds of dark-coloured shale. In the latter position it sometimes appears in the form of concretions; but more frequently in irregular bands, seldom more than one or two feet in thickness. The outer surface of this *crow-limestone* is very irregular, and is generally covered with a thin, earthy coat of hydrate of iron. It is very ponderous, in parts reaching the specific gravity of the nodules of argillaceous iron ore. It is difficult of fracture; but when broken almost always shows a bluish, calcareous interior; and rarely has a core of nearly pure limestone.

It contains innumerable organic remains, especially large specimens of a species of Producta; and from the crescent-shaped impressions of that shell, the miners sometimes designate it by the name of horse-shoe limestone*. It

* The specific characters are generally obscure; but I believe the large Productæ belong chiefly to the species *Producta Scotica.*

is obvious, that it owes its existence to the accidental presence of beds of shells (chiefly of the genus Producta), during the deposits of the great masses of shale—that these shells supplied a considerable portion of the calcareous matter—and that they also caused the precipitation or separation of the ferruginous and pyritous matter, and of the other constituents commonly found together in these *calliards*.

In the upper division (*c*.) of the group here described, there is in some places a band of coal: but as it is in general not more than a few inches in thickness, it has never been worked to any profit*.

5. *Strong Post Limestone.* Thickness nearly the same as the black marble series (No. 3.), averaging about 30 feet.

This group, in its mode of bedding, in its colour, and in the dark bands of shale which alternate with the strata, nearly resembles the black marble system. The beds are however stronger, thicker, and coarser; and though generally unfit for polishing, afford a beautiful material for the construction of door-posts, small pillars, coignes, coping-stones, &c.†

I have traced this group in the position here indicated, through the flanks of Ingleborough, Penigent, and Whernside; all round the valley of Dent; through the upper part of Garsdale; and through a part of the chain of hills between Wensleydale and Swaledale. There can, therefore, be no doubt of its continuity through all the country bordering on the southern and central part of the principal section.

6. *Alternations of Fissile Gritstone and Carbonaceous Shale.* Greatest thickness 150 feet; average thickness about 120 feet. The alternations are indefinite; but on the whole the group may be conveniently separated as follows.

(*a*.) Alternations of gritstone and shale; the gritstone sometimes rising in strong beds; but more frequently micaceous and of a flaggy structure.

(*b*.) Carbonaceous shale and gritstone with a band of coal; also with two thin bands of *crow-limestone* or *calliard*.

(*c*.) Hard, brown, and light grey, micaceous grit, with bands of shale; the micaceous grit in some places highly fissile, and forming a good roofing slate.

The most important bed in this group is the coal in division (*b*). It is ex-

* I have been informed that works were formerly opened in this bed at Load Gill on the south side of Dent, and also on the north side of Garsdale, but with very little success.

† Attempts have, I believe, been made, but without success, to polish some of the darker beds containing many very small encrinital stems. A small, dark-coloured, encrinital marble, found in Derbyshire, and other parts of the carboniferous chain, is provincially called *bird's-eye marble*; and is occasionally found subordinate to the black marble group.

tensively worked in the Barbon and Casterton liberties, where it is about fourteen inches thick. The lower part of this bed is however so impure, as to be unfit for domestic use, and is chiefly consumed in lime-works*. An attempt is now making to work the same bed in the adjoining liberty of Dent†. It is also worked at Stoth pits near Hawes, in Baw Fell above Sedbergh, and at Kitchen Gill on the side of Naitby Fell near Kirkby Stephen; and there are many traces of old works in the same bed near Garsdale Head‡. I am certain that in all these places the coal is very nearly on the same geological parallel. It must therefore have been very widely extended. But it was by no means continuous, as is proved by innumerable sections through this group, which perpetually varies in its composition, and in which there is often no indication whatsoever of the coal-bed. It deserves remark that the two thin *calliard* beds appear to be continuous for many miles.

The slate-beds in division (*c*.) are next in importance. They have been extensively worked in several places; especially at Wydern and Kirkbank in the valley of Dent: but the most beautiful example of these beds is in Cow Gill, about five miles above the village, where there is a quarry of hard, white, siliceous grit capable of being split into very thin flags, coated with silvery mica, and forming the most beautiful roofing slate I have seen in the carboniferous chain.

7. *Mosdale Moor or Wold Limestone*§. Average thickness from 30 to 40 feet.

* Section, in descending order, from the shaft of the Barbon coal-pits:—

	Feet.	Inch.
1. Alluvial soil, &c.	52	6
2. Plate (*calcareous shale*)	1	6
3. Limestone (the fourth, or Mosdale Moor limestone, of the general section)	27	0
4. Gritstone	27	0
5. Alternations of gritstone and shale	12	0
6. Shale	30	0
7. Crow-limestone	2	0
8. Plate, with a three-inch crow-coal	1	6
9. Gritstone	27	0
10. Coal	1	2

The crow-limestone (No. 7.) more commonly appears in the form of two distinct bands separated by a bed of impure, pyritous shale. In this section, the beds seem to have run together; probably by the partial disappearance, or thinning out of the pyritous shale.

† The attempt was unsuccessful, and the works have been deserted since the above passage was written.

‡ I have been informed that the coal of Kitchen Gill is eighteen inches thick; but I have seen no accurate sections of the works. In the places where it has been most worked the average thickness of the bed is not much more than a foot.

§ The group is known in some of the valleys under the name of *Wold-limestone*: as, however, this word designates any tract of dry green pasture land rising out of the morasses of the carboniferous chain; and as this kind of soil marks, more or less, the range of all the calcareous groups; the term *wold* is a bad distinctive name for any one of them.

This limestone is less regularly bedded than the two preceding groups (Nos. 3. and 5.). The bottom beds are generally of a grey colour and of an open, shaken texture. They are frequently surmounted by two or three coarse, strong beds of a grey colour, not to be mineralogically distinguished from the most ordinary varieties of the *great scar limestone*, containing various fossils, apparently distributed without regularity. The higher beds become thinner, more compact, and sometimes contain many encrinital stems, and are occasionally of a dark colour. In the highest part of the series, the beds alternate with bands of dark shale, become impure and ferruginous, and frequently pass into the state of *crow-limestone* or *calliard*, with many large Productæ.

Detailed sections of this division would, no doubt, offer many modifications; but few quarries have been opened in it, since it contains no beds of any peculiar value, and many parts of it are obscured by alluvial accumulations. It may, however, be tracked without any difficulty, wherever it rises to the day, along the sides of all the mountains which range near the lines of section; as well as in all the various systems of valleys which branch among the mountains between Askrigg and Kirkby Stephen. It has indeed been important to make out its continuity, as it forms the roof of a series of beds to which the Barbon coal seam is subordinate (No. 6. (*b.*))

8. *Alternations of Sandstone, Fissile Gritstone, and Shale.* This is by much the most remarkable of all the groups alternating with the beds of limestone. Its greatest thickness is perhaps as much as 350 feet; and its average thickness in the central and southern parts of the section is about 200 feet.

Like all the other masses composed of sandstone and shale, it is extremely variable in its structure, the subordinate parts either disappearing or replacing each other. In some places the alternations are indefinite: but on the whole it admits of the following approximate subdivisions.

(*a.*) Alternations of slaty, micaceous gritstone and shale, sometimes containing bands of *crow-limestone*.

(*b.*) Shale with bands of gritstone.

(*c.*) Micaceous, fissile gritstone with thin bands of shale, and with subordinate masses of coarse gritstone.

There are very fine quarries in the lower division (*a.*), especially at Rawthay Gill (between Ravenstone Dale and Sedbergh), where in colour the gritstone somewhat resembles the Pennant stone of Bristol; but is more micaceous and fissile, and generally of a more open grain. In the higher part of the upper division (*c.*), the fissile beds have been extensively worked

for roofing slate and flagstone, (*e. g.* Garsdale Hall pastures, High Pike in Dent, and all round the upper precipices of Ingleborough, &c. &c.) They are generally of a dark bluish grey colour, and are liable to decomposition. Round Ingleborough they are however of a brownish grey colour, and of a closer texture. Strong beds of grey sandstone occur in the lower part of this division (*c.*); which sometimes, though very rarely, become of so coarse a texture as to resemble millstone grit.

Two thin bands of bright coal have been found (at Rawthay Gill and Ingleborough), one in the lower (*a.*) and the other in the upper division (*c.*) of this group: and between Brough and Stainmoor (to the north of the line of section) it contains a bed of coal, which has been worked to a considerable extent.

In some of the hills near the head of Wensley Dale (*e. g.* Stag's Fell near Hawes, &c.) the shale-beds almost disappear; and the group passes into a complex deposit of hard, grey, micaceous gritstone, some parts of which afford a good building-stone, and other more fissile parts, a material for flagstone and roofing slate.

9. *Four-fathom Limestone.* Notwithstanding the name by which it is designated in the mining districts of the North of England, this limestone group is of much more variable thickness than any of the three preceding (Nos. 3. 5. 7.): but I believe that it in no instance entirely disappears. In some places it is not more than ten or twelve feet in thickness; in others it is much more expanded, and is not less than thirty or forty feet thick. Changes ranging within these limits are several times repeated, as may be proved by tracing these beds through the mountains at the head of Dent and Garsdale. Its average thickness in these regions is perhaps less than that which is indicated by its name. The bottom of the series, as usual, is impure, and is deposited in irregular, grey beds with traces of fossils. The middle portion is much more regularly bedded, and contains innumerable fossils, especially encrinital stems. Indeed, where the middle and upper portions of this group are largely developed, we find that large encrinital stems form the greater part of the substance of the successive beds; and where the same portions are ill developed, the stems are fewer in number and less in size*—a fact, which shows the large share these extraordinary fossils had in the formation of the several beds.

At the top of this group we here and there find cherty, siliceous beds, with casts of encrinital stems (like the well-known Derbyshire *screw-stones*) alternating with bands of calcareous shale, containing innumerable, flattened Productæ. These beds, though unimportant in themselves, offer us a valuable

* In the hills south of Dent the variety called *bird's-eye marble* abounds in this group.—See above, Note † to page 75.

analogy by help of which we compare them with the cherty beds in the *four-fathom limestone* of the mining districts of Swaledale and Arkendale.

The strongest masses of this group (in which the fossils are all more or less white and crystalline, and imbedded in a dull grey, nearly compact limestone), are, on the north side of Garsdale, extensively quarried for the Kendal marble works; and works were opened on the corresponding strata in the valley of Dent, but are now deserted; a better material having been there discovered in the *twelve-fathom limestone*.

10. *Gritstone, Coal, and Shale.* Thickness varying from 50 to 80 feet.

The prevailing order appears to be nearly as follows:

(*a*.) Thin-bedded gritstone, sometimes coarse-grained.

(*b*.) Coal and carbonaceous shale.

(*c*.) Bands of light-coloured, micaceous grit.

The lowest division (*a*.) is of very variable structure. It is in some places very coarse-grained; but in Uldale, between Swath Fell and Baw Fell, it passes into a dark, compact, siliceous mass, exactly like the metalliferous chert of Swaledale. Along the line of section this cherty form is, however, an exception to the prevailing structure. The coal varies in thickness from a mere trace to two feet, and is in many places of excellent quality*. When it reaches its maximum thickness, it is, however, generally mixed with shale and other impurities. To the north of Ingleborough, no member of the whole series is more continuous than this coal-bed and its superincumbent shale; and it has been worked, more or less, in almost every mountain near the lines of section. But in Ingleborough and Penigent the whole group here described thins out to such a degree, that the *four-fathom* and *twelve-fathom limestones* become confounded, and present a single unbroken escarpment. To the north of the line of section the same coal is now extensively worked in the neighbourhood of Brough.

11. *Twelve-fathom Limestone.* This system of beds makes a striking feature in many parts of the carboniferous chain of the North, being the highest limestone group of sufficient thickness to give any character to the soil or to produce a distinct escarpment. In some districts it forms the crown of a long

* This coal was formerly worked to a considerable extent, by means of horizontal drifts, under Great Colm, on the south side of the valley of Dent, though not more than five or six inches in thickness. It was of excellent quality, and in such request, that about seventy or eighty years since, it was sent on pack-horses over the mountains as far as Kendal for the use of the blacksmiths' forges, &c. I know of no fact which places in a more striking point of view the great improvements in internal communication within the period above mentioned. A supply like this would now be utterly worthless. The extensive manufactories of Kendal have long been supplied with fuel from the great Lancashire coal-fields.

succession of tabular hills; in others, it forms a terrace on the sides of the mountains terminating a succession of green pastures, which rise in interrupted slopes from the neighbouring valleys. Above it the strata often lie concealed under accumulations of black turf bog; and the highest summits of the mountains terminate in great irregular masses of tabular millstone grit. Near the line of section its greatest thickness is about eighty feet; but in one or two places it thins off and almost comes to an edge; and its average thickness is under twelve fathoms.

The mineral characters of the group are so nearly the same with those of the *four-fathom limestone*, that the same description may almost serve for both. Its prevailing colours are grey, and some of the beds exactly resemble ordinary specimens of the *great scar limestone*. Most commonly this group is distinguished by the abundance of encrinital stems, which in some rare instances so nearly constitute the whole mass of the strata, that the cementing principle is almost wanting, and the weathered surfaces of the blocks rapidly disintegrate and fall into innumerable cylindrical fragments*. In general, however, the encrinital fragments are held firmly together by a grey, subcrystalline, calcareous cement, and form hard beds, the most regular of which admit of a good polish. The most beautiful variety of this fossil marble, is obtained from one or two of the upper beds of this group, and is quarried at Snays-wold Fell, between Dent and Garsdale. The dull grey base in which the fossils are commonly imbedded, is there enlivened by many dark cloudy blotches, arising out of the irregular distribution of the colouring bituminous matter. The group appears to terminate in a few, thin, impure beds of dark bluish limestone alternating with slaty gritstone and carbonaceous shale†.

So far the relations of the successive groups may be ascertained with a near

* Beds of this kind burn to a pure lime very readily: but on extracting it from the kilns, instead of coming out in such lumps as are convenient for transport, the lime frequently falls at once into a fine impalpable powder. Some beds of this kind overlie the coal-seam (No. 10 (*b.*)) at a hill called The Cross in the valley of Dent.

† Section of the marble quarry of Snays-wold Fell, in the descending order:—

	Feet.	Inches.
1. Carbonaceous shale	4	0
2. Flaggy, brown grit	1	0
3. Hard, dark blue, impure limestone	2	4
4. Shale and gritstone irregularly mixed together, and containing much calcareous matter in nodular masses, with large stems of Encrinites	0	10
5. Hard, dark blue limestone, and a thin band of shale	1	6
6. Fine, compact bed, with crystalline stems of Encrinites	1	10
7. Shattered beds and shale	0	6
8. Strong Encrinite bed	3	0
9. Lower calcareous bed, not exposed in the section.		

Nos. 6. and 8. are the only beds used in the marble works.

approach to accuracy, as the various limestone deposits offer a series of good base lines to which all the distant observations may be referred. But in the remaining part of the ascending series we lose all our lines of verification; and the sections, as might have been expected, differ very widely in their details. Out of much apparent confusion, we may, however, make out an approximate order, and divide a great thickness of strata into groups sufficiently extended to admit of a general comparison among themselves.

12. *Great upper Shale.* Thickness varying from 40 or 50 to nearly 200 feet.

This group is complex, containing, here and there, a band of *crow-limestone*, and having many subordinate masses of grit, generally of a thin, slaty texture. On the whole, however, it is characterized by a dark-coloured shale, and makes a remarkable feature in the higher parts of many of the mountains, being often laid bare by the deep water-channels which intersect the boggy region between the *first millstone grit* and the *twelve-fathom limestone*.

On the south side of Baw Fell (in the brow above the marble quarry mentioned above (p. 79.)), a five-inch coal is, I believe, subordinate to this group; and, on the west side of the mountain, it contains a strong band of *crow-limestone*. In a part of Swaledale it contains the *main chert, black beds, red beds, iron beds*, &c. enumerated in the detailed sections of the miners in that district.

13. *First Millstone Grit.* Thickness varying from 20 to 60 feet.

The term is here used with considerable latitude, being applied to a group of strata, a part only of which has the true character of millstone grit. When used more strictly, it designates a coarse, open-grained, siliceous gritstone very irregularly bedded, often subdivided by lines not parallel to the planes of stratification, and usually containing a considerable quantity of kaolin, and small rounded pieces of opaque quartz interspersed irregularly through its mass.

The prevailing colour of the group, here described, is light grey; but this is by no means constant. The characteristic millstone grit is sometimes found associated with all parts of this group; sometimes only with the upper part; in which case the lower beds generally consist of a hard, light grey, thin-bedded sandstone. Sometimes the millstone bands are entirely wanting, and then the group (especially when the beds alternate with shale) cannot be easily separated from that which is next superior to it.

It is finely exposed in the last precipice of Penigent, and in the strata which form the crown of Ingleborough. It also forms a part of the higher escarpment of Whernside and of Great Colm*.

* The open-grained varieties of gritstone in this group sometimes decompose into a sharp siliceous sand, which is much used in the saw-mills where the marble blocks are divided into thin slabs fit for polishing.

14. *Alternations of hard, thin-bedded, brown gritstone, and dark-coloured carbonaceous shale, with two or three beds of coal.* Average thickness along the principal line of section about 60 feet.

In some of the neighbouring regions (for example among the mountains of Swaledale Head), this group contains two or three thin beds of *crow-limestone,* and its aggregate thickness is about 200 feet.

The only bed of coal which has been much worked, is in the lower part of the group, and varies from eighteen inches to nearly four feet in thickness. At Tan Hill near the highest part of the road from Brough to Arkendale, and at Turna Fell near Hawes, this coal is of good quality, and is extensively worked. Near the top of Penigent, of Whernside, and of Great Colm, horizontal drifts have been carried into this bed; but it is of bad quality, and not fit for domestic use, being mixed with ferruginous and pyritous shale*. The hard, brown beds of grit alternating with the carbonaceous shale, are provincially termed *sill-stones.*

15. *Second Millstone Grit.* The limits of this group are very ill defined, and its thickness varies from 40 or 50 to 120 feet.

At the top of Penigent and Whernside it is represented by an open-grained, thin-bedded, siliceous grit, no part of which has the appearance of millstone. But at the top of Baw Fell, Wildboar Fell, and some of the Swaledale hills, it passes into great, thick beds of the finest millstone grit.

16. *Alternations of gritstone and shale, with traces of a thin bed of coal.* Thickness about 100 feet.

The band of coal is found, here and there, near the bottom of this division. In general the subordinate shales are meagre, sandy, and micaceous; and the alternating beds of grit are thin and open-grained, like certain bands associated with the groups of millstone grit.

There is just a trace of this group at the top of Wildboar Fell, and perhaps at the highest point of Whernside, under the soil and morass. It is best exposed under the highest summit of Shunner Fell, and near the top of a part of the high ridge between Mollerstang and Swaledale Head.

17. *Upper Millstone Grit.* Thickness 120 feet.

* As not less than three beds of coal are found, here and there, subordinate to this group, it would be impossible to prove that in all the above-mentioned places the coal is precisely upon the same parallel. It is, however, so considered by the miners of the neighbouring districts. Near Kirkby Stephen it generally passes under the name of the *Tan Hill seam,* that being the locality of the most valuable coal work, established upon the bed in question. There, however, the relations of the coal to the neighbouring groups are somewhat obscure; and in a general description the *Turna Fell seam* is perhaps the best name which can be given to it.

A most characteristic exhibition of this group is seen at Shunner Fell top, and on some other of the highest eminences of Swaledale; but it does not appear anywhere upon the longitudinal line of section. Like the other groups (Nos. 13. and 15.), it varies in structure; but it contains, and passes into, masses of the most characteristic millstone grit.

Here terminate the details of the general section; and with one limited exception, no higher beds appear among the mountain ridges extending from Penigent to Stainmoor, and to the mining districts of Arkendale and Swaledale.

Before commencing the description of the longitudinal section, it may be expedient, for the purpose of easy reference, to give a tabular view of the preceding detailed general section.

Carboniferous limestone series, &c., in the descending order.*

	Greatest thickness in Feet.
17. Upper millstone grit, &c.	120
16. Gritstone and shale, with traces of a thin bed of coal	100
15. Second millstone grit, &c.	120
14. Alternations of hard gritstone, shale, and two or three beds of coal. Mean thickness about 60 or 70 feet	200
13. First millstone grit, &c.	60
12. Great upper shale	200
11. *Twelve-fathom limestone*	80
10. Gritstone, coal, and shale	80
c. Bands of grey, micaceous grit. *b*. Coal and shale. *a*. Thin-bedded grit.	
9. *Four-fathom limestone*	40
8. Sandstone, fissile gritstone, and shale	350
c. Micaceous, slaty grit, with bands of shale and a trace of coal. *b*. Shale with bands of gritstone. *a*. Slaty, micaceous grit and shale, sometimes with a trace of coal.	
7. *Mosdale Moor or Wold limestone*	45
6. Fissile gritstone, and carbonaceous shale, with a bed of coal	150
c. Hard, micaceous, slaty grit. *b*. Shale, coal, and grit. *a*. Grit and shale.	
5. *Strong post limestone*	45
4. Sandstone, shale, and calcareous grit	150
c. Hard, brown grit, shale, and a trace of coal. *b*. Siliceous and calciferous grit. *a*. Dark shale.	
3. *Second limestone or black marble group*	45
2. Sandstone and shale	150
c. Hard micaceous grit and shale, &c. *b*. Sandy, micaceous shale and brown sandstone. *a*. Dark shale and iron-stone.	
1. *Great Scar limestone*	600
Total	2535

* Pl. VI. fig. 1.

The thickness from the bottom of the whole system to the top of the *twelve-fathom limestone* is 1735 feet, as determined by these numbers; and from the top of the *great Scar limestone* to the top of the *twelve-fathom limestone*, is 1135 feet. But a small correction must be made on account of dip; and a more considerable correction on account of over-estimate, all the beds being taken at the maximum thickness, which is never the case in any one section. After all the deductions, there must remain a thickness of about 1000 feet for the alternating beds between the top of the *great Scar limestone* and the top of the *twelve-fathom limestone;* and as far as regards the mountains of Garsdale and Dent, I do not think that this is an over-estimate. It is, however, right to state, that very few of the numbers in the preceding details are from actual measurement. I wish them to be considered only as the average results of a great many independent approximate observations.

§ 3. *Longitudiual section from Penigent to the plains of the Eden near Kirkby Stephen, &c. &c.**

This section might have been extended many miles further towards the south, through a region which, though of less elevation than the one here described, has nearly the same external characters, and is composed of similar groups of strata: but I wish to confine it to the part of the chain I have personally and repeatedly examined.

Commencing at the top of Penigent, it passes just above the village of Horton, and thence nearly in a straight line to the top of Ingleborough. The summit of Penigent is, I believe, composed of beds subordinate to the *second millstone grit* (Group 15.); and immediately below, the highest slope, Nos. 14. 13. 12, are finely exposed, and the coal bed of No. 14. has been worked in horizontal drifts. Then comes a great limestone precipice representing Nos. 11. 10. and 9.—No. 10. having nearly disappeared, and the *twelve-fathom* and *four-fathom limestones* (Nos. 11. and 9.) making but one precipice. The remaining part of the great escarpment is composed of No. 8.

From the swallow holes at the base of No. 8. to the level of Horton Beck, all the successive beds (No. 7. to No. 1.) may be traced without a single omission. The *black marble beds* (No. 3.) have been quarried above Hull Pot, but are not of good quality; and the group (No. 2.) is not more than twenty or thirty feet thick†. The great *Scar limestone* is magnificently exhibited; and in it are Hull Pot and Hunt Pot. The former a great roofless

* Plate VI. fig. 2.

† Both in Ingleborough and Penigent the groups between the *Scar limestone* and the *twelve-fathom limestone*, are of less aggregate thickness than in many other parts of the principal section.

cavern, with perpendicular walls, from which may be heard the roaring of subterranean waters. The latter, an open crevice of unknown but great depth, as is proved by the long-continued rumbling noise of the stones which descend after many rebounds from its projecting ledges towards the foundations of the mountain.

Below Dowgill Scar is a beautiful junction of the horizontal limestone and inclined greywacké without the intervention of any conglomerate*. In the prolongation of the section through Moulton Fell, the *Scar limestone* presents no features deserving peculiar notice; but a little to the east of the line, above the village of Selside, is an open chasm called Alum Pot, of enormous but unknown depth. It is surrounded by grassy shelving banks, and many animals tempted towards its brink have fallen down and perished in it†.

Further up the hill (at Moor Syke, &c.) are the black marble beds (No. 3.), and after passing in succession all the intervening beds, we have, at the top of Simon Fell, the slate quarries of No. 8. *c*. The upper portion of this group makes a magnificent precipice on the north side of Ingleborough, and its slate quarries may be traced all round the mountain. Over this group comes a precipice of limestone, in which (as at Penigent) the *twelve-fathom* and the *four-fathom limestones* are united, the intervening shale and coal (No. 10.) having nearly disappeared. Over these comes the *upper shale* (No. 12.); and then the *first millstone grit* (No. 13.), forming a great tabular mass on the top of Ingleborough. The two highest groups of the Penigent section are therefore wanting.

In descending from the great precipice of slaty grit and shale to the river of Chapel le Dale, we pass in regular succession over every group from No. 8. to the bottom of the *Scar limestone*. The upper groups are much concealed by morass, but they break out, here and there, and are laid bare in the water-courses on the sides of the mountain. In the bottom of the valley (about half a mile below the Chapel) there is a beautiful junction of the horizontal limestone and the inclined greywacké; and just at that point all the mountain streams, which in the higher part of the valley had been engulfed in the cavernous *Scar limestone*, burst out in one copious spring, and form the river which descends to Ingleton.

Following the line of section, we have at the base of Whernside some of

* The greywacké dips about south by west, at an angle of 45°.

† The approach of cattle is now prevented by a strong, lofty wall; but there can be little doubt, that during the last two or three thousand years, great masses of bony breccia must have accumulated in the lower parts of this great fissure, which probably descends through the whole thickness of the *Scar limestone*.

the most characteristic features of the *Scar limestone*. It is traversed by fissures, and hollowed out into caverns; in one of which (Weathercoat Cave) is a waterfall of no common beauty, and doubly striking from the extraordinary nature of the objects which are about it.

Ascending thence to the top of the mountain, we cross the groups in regular succession, and end with a series of thin-bedded, coarse grits, nearly on the same parallel with the beds on the top of Penigent, and therefore probably subordinate to No. 15. of the general section *.

The *first millstone grit* (No. 13.) makes a feature on all sides of the mountain top, and the coal bed in No. 14. has been partially opened on its north face. The coal bed in No. 10. (*b*.) has been worked in three or four different places, and the group to which it is subordinate becomes regularly expanded (though probably of rather less than its mean thickness) between the *twelve-fathom* and the *four-fathom limestones*. Here, therefore, ceases the anomaly of the Ingleborough and Penigent sections already noted; and it is, as far as I know, the only great anomaly in the structure of the districts through which the lines of section range. There is, however, a peculiarity (and it is repeated on the east side of Great Colm) which deserves notice. The *four-fathom limestone* all round this mountain is thicker than the *twelve-fathom limestone*, one group being developed much beyond its average thickness, and apparently at the expense of the other †.

From Whernside the line deflects nearly due west (without producing any confusion in the details, as all the groups are very nearly horizontal), and ranges by High Pike across the pass from Dent to Ingleton ‡. The *four-fathom limestone*, and the slate quarries (No. 8. *c*.), form the top of the ridge; and on the north-east side of it, is a succession of waterfalls over the bare escarpments of all the groups, from the *fourth limestone* (No. 7.) down to the beds above the black marble series. Through the middle portion of these falls, runs a north and south vein (partly filled with calc-spar), producing a downcast of eight or ten yards on its west side. I mention this for the pur-

* The natural section is not good near the top of Whernside, the highest mountain of the whole range; but the top beds may possibly represent a portion of the 16th group of the general section.

† This fact has sometimes induced me to suppose that the great calcareous escarpment near the top of Ingleborough and Penigent was chiefly composed of the *four-fathom limestone;* and that some bands of shale and thin beds of limestone near its top, might represent the two superior groups (Nos. 10. and 11.) in a very degenerate form. I mention this only as a mere conjecture.

‡ In the southern and central portions of the principal line of section, the beds, though nearly horizontal, incline on the whole a little to the north-east. The part of the section deflecting nearly due west, from the top of Whernside over High Pike to Great Colm, is omitted in the accompanying figure (Pl. VI. fig. 2.).

pose of remarking the almost entire absence of great faults or veins in the neighbouring mountains, and their consequent sterility in all metalliferous minerals.

From High Pike to the top of Great Colm, all the groups succeed each other in regular order; but on that side of the mountain the *twelve-fathom limestone* is still in a degraded form, and the *four-fathom limestone* has more than its average thickness. On following them to the eastern side of the mountain we may, however, remark, that one gradually increases and the other diminishes in thickness till they assume their average proportions. Over the *twelve-fathom limestone* (No. 11.) the three superior groups are well exhibited; and a bad two-foot coal has been partially worked in the group No. 14, which is here about 60 feet in thickness. On the highest summit is a trace of the *second millstone grit* (No. 15.), which, though rather thin-bedded, has here the mineral structure indicated by its name. I do not, however, think that these beds are so high in the series as those which form the highest peaks of Penigent and Whernside. Here the section again deflects to the north, and in the remaining part of its range is very nearly in a straight line*.

Descending from Great Colm top to the valley of Dent we commence, as above stated, in the lower portion of the *second millstone grit* (No. 15.), and cross in succession every group till we meet the upper strata of the *great Scar limestone,* about 200 feet above the level of the river. We may remark, during this traverse, the old coal-works in No. 10. (*b.*) †,—the slate quarries of Little Colm in No. 8. (*c.*),—the old slate quarries and the Barbon coal-works in No. 6. (*b. c.*),‡—and the various quarries which have been opened in the *black marble beds* (No. 3.).

In the higher part of the valley of Dent the river runs for several miles among the upper beds of the *Scar limestone,* and we meet with a succession of objects highly characteristic of the formation. The mountain-streams are engulfed, and the strata interrupted by numberless grotesque caverns and open fissures, resembling, on a miniature scale, the striking features of Chapel le Dale.

From Dent, the sectional line ranges over the top of Risell to the Garsdale river, close to the chapel. On the ascending line, all the beds are laid bare up to the *Wold or Mosdale Moor limestone,* in a great ravine called Scotchergill. On the eastern brow of Risell are quarries in the *four-fathom* and *twelve-fathom limestones;* and from the upper quarry is obtained a very beautiful variety of fossil marble already noticed. On the western brow of the same hill, the coal-bed (No. 10. *b.*) has been partially worked; and the summit is composed of the lower beds of the *first millstone grit* (No. 13.).

* See Pl. VI. fig. 2. continued.

† See above, Note to p. 79.

‡ See above, Note to p. 76.

On the descending line there is a fine exhibition of the slate quarries in No. 8. *c*. Close to the chapel the river runs in the grit bands (No. 2. *c*.) under the black marble; but in ascending to Garsdale Head (where the road turns off to Kirkby Stephen), all the beds up to the fourth *Mosdale Moor limestone* (No. 7.) may be observed to cross the channel in succession.

Both sides of Risell are much covered with alluvial matter and vegetation; but independently of the localities above indicated, the position of the respective groups is defined by the rows of inverted green cones, provincially called *swallow-holes*, which often mark the presence of the limestone bands when no rock is visible at the surface. From many places, on the line of section, five rows of these inverted cones, each indicating the presence of one of the calcareous groups above the *Scar limestone*, may be seen on the sides of the neighbouring mountains*.

In ascending from Garsdale chapel to the top of Baw Fell we may find, by the sides of various torrents, good sections of all the groups, from the *black marble* to the *twelve-fathom limestone*. A thin coal band breaks out, here and there, in the group (No. 4.) above the *black marble beds*. On the west flank of this mountain, the coal bed (No. 6. *b*.) under the *Mosdale Moor limestone* has been worked extensively; and on the same flank the coal bed under the *twelve-fathom limestone* has been attempted†. The quarries in the *four-fathom limestone*, from which large encrinital blocks are extracted for the use of the Kendal marble works, also deserve notice.

The groups of strata above the *twelve-fathom limestone* are of the aggregate thickness of 500 or 600 feet, and terminate at the top of the mountain in fine, horizontal, tabular masses of millstone grit, subordinate, if I mistake not, to the second group of that rock (No. 15.). All the upper parts of the

* The origin of these cones is very clear. The several limestone groups abound in crevices and fissures, through which the waters, descending from the higher regions, immediately sink, and trickle down among the lower strata, till they meet some impervious bed which throws them out again to the surface. Now on the sloping sides of the mountains these groups generally form long horizontal terraces, more or less buried under masses of alluvial, incoherent matter: and through this covering the waters freely percolate, till they meet the surface of the limestone beds; when they sink, as above described, through some of the crevices, and carry along with them the finely comminuted portions of the superincumbent materials. In this way the alluvial beds are slowly undermined, and sink down into inverted cones—the inferior portions of which, being sheltered from the elements, and kept dry by the action of the crevices below, become covered with a fine green sward abounding in such plants as are commonly found only in the lower regions of the mountains.

† Not far below the works in No. 6. *b*. a trial was made, a few years since, in some highly inclined, carbonaceous shales, probably subordinate to No. 4. of the general section. The coal was abundant, but of very bad quality, and difficult to work; being close to the disturbance produced by the passage of the *great Craven fault*. See the preceding Memoir, p. 60.

section are extremely obscured by morass; but we have, I think, evidence enough to show—that a five-inch coal (breaking out about 100 feet above the *twelve-fathom limestone*) is subordinate to the great upper shale (No. 12.), which is here very largely developed,—and that a second bed of four-inch coal, about 200 feet above the preceding, is subordinate to the alternating beds (No. 14.) above the *first millstone grit.* The evidence for this arrangement may be considered obscure; but it is at least made probable by the structure of the nearest mountains of the chain.

Descending from Baw Fell top to the head of Uldale (after crossing a region of thick morass), we meet with magnificent sections of a great series of beds commencing with the *twelve-fathom limestone.* Under this limestone the coal bed (No. 10. *b.*) has been partially worked. We then cross a series of cherty beds, analogous to those on the same parallel in the Arkendale and Swaledale sections: and further down the torrent is a great precipice (composed of the *four-fathom limestone,* resting on the gritstone bands and thick shales of No. 8.), over which the waters shoot in a single plunge, and form one of the grandest falls in the carboniferous chain*. Below the fall is one of the finest gritstone quarries of the chain (No 8. *a.*); and a few hundred yards further down the valley we find great masses of highly inclined and dislocated limestone, connected with the range of the *Craven fault.*

The phenomena, last described, are a little to the west of the line of section, which at Uldale Head makes its nearest approach to the greywacké region. Thence it ranges over Swath Fell, to the top of Wildboar Fell, through a country almost buried under turf bog and alluvial soil. The top of Swath Fell appears to belong to the same group (No. 15.) as the top of Baw Fell, but it does not quite reach the same elevation.

At the top of Wildboar Fell we have just a trace of the group (No. 16.); but

* In all chains of mountains composed, like those I am describing, of horizontal strata in very different degrees of induration, waterfalls are necessarily abundant. The harder groups have an obvious tendency to form terraces over which the waters break with a violence proportioned to the nature of the descent. The steep sides of the hills are, however, often composed of solid beds of sandstone or limestone, resting on thick masses of soft, incoherent shale: and when such combinations cross the direction of a mountain stream, they almost always produce an overshot fall. For, had the inferior shales ever projected so far as to produce a gradual descent, they must soon have given way to the friction of the water, till they arrived in such a position as to be protected from its action. And even when removed from the direct effects of erosion, they often continue to exfoliate so rapidly, that the hard superincumbent beds form a projecting ledge, over which the waters leap at once into an inferior basin. In this way the great waterspout of Hardraw Scar commences in the black marble group, and plunges into a basin of the shales subordinate to No. 2. These appearances are so very common and obvious as perhaps hardly to require notice.

the magnificent tabular escarpment overlooking Mollerstang is composed exclusively of the *second millstone grit* (No. 15.); and on the same face of the mountain we have a succession of the finest sections, exposing all the groups down to the *twelve-fathom limestone*. They are, perhaps, of as great a thickness as at Baw Fell; but in consequence of the degenerate form of the *first millstone grit* (which is here an ordinary, open-grained, whitish sandstone), they are not well defined. Subordinate to No. 14. is a bed of coal about eighteen inches thick, which has been partially worked, but hitherto without profit.

Descending from the crown of the hill, along the edge of its eastern escarpment, to the level of the white grit beds representing the *first millstone* (No. 13.), we cross (close to a place called Dolphin Sty) the line of a great vein or fault, which throws all the beds on its north side about 150 feet below their level. In consequence, the coal-bed (No. 14.) and the accompanying grits and shales are once again repeated. This vein strikes the opposite hills (producing the same northern downcast), and is prolonged into the mining district of Swaledale.

After reaching the level of the *twelve-fathom limestone*, we cross the bearings of one or two other veins, which have partially deranged the position of the groups. I have attempted to convey only a general notion of them in the accompanying section, for the country is so much covered with alluvion that their exact effects cannot be easily ascertained.

Continuing to descend, we come upon the edges of the dislocated masses thrown up by the *great Craven fault*. The horizontal beds of the *great Scar limestone* lie far below the bottom of the neighbouring valley*: but the broken ends of the whole mass have been torn up from the foundations of the mountain, and jammed against the edges of the upper horizontal groups. The vast force of elevation is indicated by the enormous extent and contortions of the dislocated masses; and the line of greatest stress is indicated by an anticlinal axis, on the north side of which the *Scar limestone*, after many breaks and undulations, gradually falls down to the level of the Eden, and is buried under the conglomerates of the new red sandstone, where the longitudinal section ends†.

* The *Mosdale Moor limestone* (No. 7.) is, I believe, the lowest calcareous group to be seen in the deep valley at the eastern base of Wildboar Fell.

† It deserves remark, that in some places near Kirkby Stephen the direction of the anticlinal axis is traced by a small vein, which, here and there, has been worked for lead. This seems to prove that, at least, *some* of the lead veins of the carboniferous chain originated in fissures produced by the great elevatory movements before the period of the new red sandstone. I believe, partly on the evidence afforded by the details of this paper, that many of the lead veins of Arkendale and Swaledale had their origin during the same period.

Such are the striking phenomena along the line of section. In order to make the structure of the region still more clear, and to connect it with the mountain tract at the head of Swaledale, I proceed to describe, very briefly, two other sections—one commencing at the top of Penigent—and the other at the top of Whernside, and both diverging considerably from the bearing of the principal line.

*Section from Penigent to the top of Stags Fell, near Hawes; mean bearing about N.N.E.**

The strata of Penigent have been already described. If the line of section be made to range along the south side of the valley, above the village of Horton, we shall arrive at the great vertical chasm called Ling Gill, which gives a series of fine, bare sections, through almost every part of the *Scar limestone.*

Continuing the section nearly in a straight line, over the summit of Cam Fell, we first cross the outgoings of all the groups up to the *twelve-fathom limestone,* forming the great plateau above Cam Houses, and find that the three groups (Nos. 9. 10. 11.) which were confounded together in Penigent, are here exhibited with their true relations. We then cross the great *upper shale* and the *first millstone grit* (No. 12. 13.), and rise to the summit of Cam Dod, which is buried under peat moss; and from that point may see the prolongation of the *twelve-fathom limestone* down Wensleydale, forming on both sides of the valley the crown of a long range of flat-topped elevations†.

Descending to Hawes, which stands upon the upper part of the *Scar limestone,* we cross all the successive groups in regular order. The coal (No. 10. *b.*) has been worked both on the east and west sides of Cam, and the lower coal seam (No. 6. *b.*) is still worked near the village of Gale.

In the range of the sectional line, on the other side of the valley, over Stags Fell, we again cross the same successive groups, in the ascending order, till we reach the great overhanging plateau of the *twelve-fathom limestone;* and we may remark, by the way, that it is traversed by a cross vein, with a *downcast* of several fathoms towards the south-east. Rising from this plateau to the top of the mountain ridge, between Wensleydale and Swaledale, we first cross the *upper shale* (No. 12.) and the *first millstone grit* (which is not far from the highest level of the road from Hawes to Muker):

* Plate VI. fig. 3.

† The summit of Cam Dod is probably composed of beds subordinate to the group (No. 14.) over the *first millstone grit.*

above them are the grits, shales, and coal bands of No. 14*; and the series, though almost lost among the accumulations of peat earth, terminates, I believe, in the beds of the *second millstone grit* (No. 15.).

Notwithstanding the constancy in the position of the several groups, there are changes of mineral structure which, had we not so many terms of comparison, might lead to some confusion. Near the eastern end of this section, the *black marble beds* (No. 3.) lose that mineral character which gives them their chief value, and resemble the beds of the higher group (No. 5.); and with these beds they might easily be confounded, as, in some places near Hawes, the shales of No. 4. are wanting, and the sandstone beds of the group are not more than twenty or thirty feet in thickness†. Near the same place the shales of No. 8. become insignificant, but the micaceous, slaty beds are well developed.

Section from the top of Whernside to the top of Shunner Fell; mean bearing about N.N.E.‡

The line here ranges from Whernside into the higher part of the valley of Dent, about five miles above the village (where the river runs upon the top beds of the *Scar limestone*); thence over the Cross to Mosdale, and over Cotter Fell to the top of Shunner Fell, without making any very great deviations in its course§.

The strata of Whernside have been already noticed, and the same groups succeed each other in regular order on the side of the next mountain, where however we may remark, that the *four-fathom limestone* is of less, and the *twelve-fathom limestone* of greater, than their average thickness; just the contrary of what was observed among the groups of Whernside; and another instance of what was remarked before,—viz., that each of these two limestone

* This coal bed is not worked, as it is only about eighteen inches thick, and is inferior in quality to the thirty-inch coal of Turna Fell, in the same range of hills, and only at a short distance towards the north.

† Further down Wensleydale these three groups of the general section (viz. Nos. 3. 4. and 5.) probably lose all distinctive character, and appear as one group: for I have remarked, that in the hills below Askrigg there are only *five*, instead of *six*, distinct limestone groups, from the *Scar limestone* (which is partially expanded in the lowest parts of the valley) to the *twelve-fathom limestone* inclusive. Between Askrigg and Bolton Castle the whole system is intersected by metalliferous veins, producing (like ordinary *faults*) contortions, *upcasts* or *downcasts*, and other disturbances of the component strata.

‡ Plate VI. fig. 4.

§ The Cross (a mountain of which the summit is sometimes called Naughtberry Hill) must not be confounded with Cross Fell, the highest mountain of the carboniferous chain north of the Eden.

groups is of variable thickness, and that each of them appears to be sometimes developed at the expense of the other*.

Above the *twelve-fathom limestone,* the *upper shale* and the *first millstone* (Nos. 12. and 13.) are in their characteristic form, and over them are the carbonaceous shales, coal bands, and grits of No. 14. and perhaps a trace of No. 15; but the summit of the hill is buried in morass.

Following the sectional line, we find in Mosdale all the beds denuded, down to the *Mosdale Moor limestone* (No. 7.); and on the east side of the valley we have an extensive tract of green pastures, crowned with a plateau of the *twelve-fathom limestone,* under which are many traces of old coal works in the group (No. 10. *b.*).

From this plateau to the top of Shunner Fell there are strata more than 100 fathoms in thickness; but all of them are buried under the peat mosses, till we reach the grey crags of *millstone grit,* on the last ascent towards the crest of the mountain. We there cross the outgoings of the *second millstone grit* (No. 15.); of the shale and gritstone (No. 16.); and we reach the highest plateau after passing the rugged escarpment of the *upper millstone grit,* the last group of the general section†.

* There is a very fine natural section of all the groups, from the upper beds of the *Scar limestone* to the *four-fathom limestone* inclusive, in the sides of a torrent called Artingill, near the old pass over the Cross between Dent and Hawes. Immediately above the highest point of this pass, are extensive coal works (in No. 10. *b.*) reached by shafts sunk through the *twelve-fathom limestone.*

† As the strata from the plateau of the *twelve-fathom limestone* to Shunner Fell top are not, on the whole, well exposed along the sectional line, I subjoin a more detailed, ascending section through the same series, as exhibited near the Turna Fell coal works, a little further to the south.

	Feet.	Inches.
1. Twelve-fathom limestone.		
2. Shale, with bands of grit	20	0
3. Quarry grit, with bands of shale	40 or 50	0
4. Sill stone (hard brownish grit) with bands of dark shale	20 or 30	0
5. Coal	2	6
6. Shale with bands of brown gritstone, and a three-inch coal near the top	70 or 80	0
7. Hard, brown grit		
8. Shale		
9. Hard, brown grit	110	0
10. Shale, with bands of soft, tough grit		
11. Bands of open, coarse grit, passing into the upper group	20 or 30	0
12. Millstone grit, &c.	120	0
13. Coarse, thin-bedded grit and shale	100	0
14. Upper millstone grit, &c.	120	0

The thickness of the beds from the coal, No. 5. to No. 10. inclusive, is very nearly thirty-three fathoms, as determined from the sinkings of an air-shaft. The other numbers are only approximate. Nos. 2. and 3. represent, in a degraded form, the *upper shale* and the *first millstone grit.* All the beds from No. 4. to No. 10. inclusive may be considered as one group, representing No. 14. of the general section: and the remaining groups represent the three highest divisions of the general section in their most characteristic form.

I could have wished to extend the two diverging sections, just described, as far as the metalliferous hills between Arkendale and Swaledale; but I am not sufficiently acquainted with that region to represent the prolongation correctly. I may, however, state in general terms, that the *four-fathom limestone* and the *twelve-fathom limestone* range through the hills on both sides of Arkendale, and are among the best lead-bearing beds of the country. They are known by the miners under the names *underset lime* and *main lime*, and are immediately surmounted by a group about 100 feet in thickness (composed of shale, chert, and gritstone, with some peculiar masses called red beds and iron beds), which, on the whole, may be considered to represent the upper shale of the general section (No. 12.). Over this group is a strong deposit of coarse grit, upwards of sixty feet in thickness, which probably represents the *first millstone grit* (No. 13.).

The coarse gritstone last mentioned is surmounted by a very complex succession of deposits about 160 feet in thickness. In the lower part of this series we have alternations of gritstone and shale, with a subordinate twelve-inch coal—over these are alternations of chert and shale, with a bed of *crow-limestone* of the extraordinary thickness of twelve feet—and the system terminates in a mass of shale about eighty feet thick, containing three subordinate bands of impure limestone. It has been stated above, that bands of *crow-limestone* are found, here and there, subordinate to all the great shales of the carboniferous chain. But their number, and the thickness of one of them, in so high a division of the Arkendale section, must be considered anomalous. I have, however, little hesitation in identifying this complex group (especially as it is immediately surmounted by a deposit of *millstone grit* nearly 100 feet thick) with the 14th division of the general section.

The preceding details of this paper explain the structure of a part of the carboniferous chain. Those which follow show the effects produced by the prolongation of the great *Craven fault*, and the movements which took place among some of the mineral masses when the chain was elevated.

§ 4. *Transverse Sections, from five points of the Longitudinal Section, through the dislocated strata on the line of the Craven Fault*.*

The first transverse section (fig. 5.) commences from the top of Penigent, and ranges (about south-west by west) through the village of Horton, over Moughton Fell; and thence over a second plateau of the Scar limestone, to the calcareous hills immediately north-east of Clapham.

* Plate VI. Transverse Sections (fig. 5. 6. 7. 8. 9.).

The successive groups of strata on the side of Penigent have been noticed above* ; and the various phenomena exhibited at the junction of the carboniferous system with the greywacké have been very clearly explained by Mr. Phillips in a preceding memoir of our Transactions†. My object is to connect the longitudinal section above described, with section (D.) of that memoir‡.

From Clapham to the hills north of Ingleton, the range of the *Craven fault* is marked by an anticlinal line or break, apparently formed by the protrusion of the slate rocks during the elevation of the limestone chain. This line passes through Clapham Beck about a mile above the village, as is indicated in the section.

The second transverse section (fig. 6.) commences at the top of Great Colm, passes in a direction nearly due south over Gragreth ; thence, deflecting a little towards the east, crosses the foot of Kingsdale and becomes united with section (A.) in Mr. Phillips's paper§.

The strata of Great Colm have been described above‖ ; but in consequence of their gradual rise towards the south-west, some of the lower groups are brought out in the Gragreth range, the top of which is composed of the fissile gritstone (No. 8. *c.* of the general section)¶. In descending from the top of Gragreth to the waterfall called Thornton Force, at the foot of Kingsdale, we cross all the groups from No. 8. down to the *great Scar limestone.* On crossing the line of the *great fault,* the dislocation is precisely of the same kind as in Clapham Beck ; but is incomparably more striking. The whole *Scar limestone* has been tumbled into the valley, and seems to pass under the Burton coal-field.

Some of the dislocated masses may be considered, in their prolongation, to reappear in the inclined beds of Kirkby Lonsdale and Farlton Knot. The principal line of fault passes however (as stated in a former paper)** by Ease Gill and Barbondale, and thence in a direction about north by east to the foot of Stainmoor. And in all this portion of its range, the nature of the dislocations of the carboniferous strata are modified by the immediate contact of a lofty greywacké chain, as will be seen in the three next transverse sections.

The third transverse section (fig. 7.) commences at the top of Crag or Casterton High Fell (the north-western extremity of the ridge of Great Colm),

* *Supra*, p. 84. † Geological Transactions, Second Series, vol. iii. p. 5—15.

‡ Ibid. Plate I. (D.) p. 12. § Ibid. Plate I. (A.) p. 9. ‖ *Supra*, p. 87.

¶ Some of the grits (subordinate to No. 8. of the general section) along this line are of coarse texture, and have been used for millstones. ** *Supra*, p. 60.

and ranging in a direction about west by north, cuts through the junction of the carboniferous and greywacké chains.

The highest strata of Casterton High Fell are of *millstone grit*; and desending in the direction above indicated, we cross every bed in regular succession down to the *strong post limestone* (No. 5. general section). But at a place called Short Gill, on traversing the line of the *great fault*, we find that all the lower groups, including the *Scar limestone*, have been torn up from the foundations of the mountain, bent into a saddle, and afterwards jammed between the edges of the horizontal beds and the steep face of the neighbouring greywacké ridge.

In order to explain this appearance, we must remember—that the greywacké chains existed in some form or other before the deposit of the carboniferous system—and that the beds of this system, before their elevation, must have abutted against a series of inclined planes presented by the submarine portions of the old greywacké chain. During a subsequent elevation, both the greywacké and carboniferous systems appear to have been violently acted on at the same moment, and a great strain, accompanied by a relative vertical movement, to have taken place all along the plane of their junction. But a relative vertical movement of the inclined flanks of the older mountains might not only break off the ends of the carboniferous strata abutting against them; but would also necessarily produce a great horizontal thrust, which may, I think, account for such a curvature of the dislocated masses as is indicated in this section.

This example has been selected on account of its complexity. There are many places along the line of dislocation, where the lower groups have been torn off, by the pressure of the greywacké hills, from the horizontal system, and tilted up at a great angle, without undergoing any flexures or contortions like those at Short Gill.

The fourth transverse section (fig. 8.) presents still more complex dislocations. It ranges nearly east and west, from the top of Baw Fell to Hebblethwaite Hall Gill, and thence across the upper part of the valley of Sedbergh to the Howgill Fells.

The west end of Baw Fell top is, if I mistake not, composed of the *second millstone grit* (No. 15. general section); the inferior groups along the line of section are much concealed under morass; but several of them may be discovered by ascending the different water-courses. The *four-fathom limestone* and the *Mosdale Moor limestone* are both well exposed, and the horizontal system terminates with flaggy gritstone and carbonaceous shale, containing a subordinate bed of coal which has been extensively worked. (General Section

No. 6. *b*.) After crossing on the descending line (immediately below the coal shale) about fifty feet of micaceous slaty gritstone (No. 6. *a*.), we suddenly come to the *great fault*, beyond which the beds dip at a high angle about west-north-west. They now *seem* to succeed each other in a regular *ascending order*; but on the contrary we find a succession of groups representing, if I mistake not, Nos. 4. 3. and 2. of the general section; and at length reach the *great Scar limestone* (No. 1.), the beds of which have a fan-shaped arrangement: the first portion dipping at a great angle in the direction above indicated,—the middle portion being elevated into broken vertical masses,—while the lowest strata gradually acquire an opposite dip (about east-north-east), and rest on the conglomerates of the *old red sandstone*.

Descending by Hebblethwaite Hall Gill, we have masses of old red conglomerate resting unconformably upon irregular, protruding beds of greywacké; and in the lower part of the valley these conglomerates become of very great thickness. From beneath them on the opposite side of the valley of Sedbergh rise the steep escarpments of the greywacké ridges in which various tributary branches of the Lune have their source*.

By comparing this description with the accompanying section, it appears,—1st, That by the prolongation of the *Craven fault* under Baw Fell, all the groups below No. 6. were cut off from the horizontal system.—2ndly, That forces of elevation, acting irregularly upon the dislocated masses, pushed a portion of the *great Scar limestone* above them all into a vertical position.—3rdly, That by this movement a portion of the *Scar limestone*, and three or four superior groups were actually inverted.

It is obvious, from this section, that great masses of old red conglomerate were formed on the flanks of the nearest greywacké hills before the existence of the carboniferous series; and the beds of this series may perhaps never have abutted against the neighbouring greywacké chain. The first effect of elevation seems to have been exactly the same with that which is indicated in the preceding section at Short Gill†. The lower groups were torn off from the base of the mountain; but not being exposed to the same horizontal thrust from the greywacké chain, they had more room to expand themselves, and fell into the remarkable position just described.

5. *The last transverse section* (fig. 9.) is drawn from the top of Wild Boar Fell (in a direction about west-north-west) through some dislocated masses, forming

* The beds in many parts of the greywacké chains, near the lines of section, are violently contorted. The lines drawn through the greywacké in the accompanying sections are ideal, and merely intended to contrast the inclined position of its strata with that of the horizontal carboniferous system.

† Plate VI. (Transverse Section, fig. 7.)

bare hills called the Clouds*, and thence to the greywacké chain of Ravenstonedale. The phenomena are here less complex than in the preceding section, though the dislocated beds have undergone a greater movement of elevation.

The top of Wild Boar Fell is chiefly composed of the *second millstone grit* (General Section No. 15.), and along the descending line we cross all the groups to the *four-fathom limestone* (No. 9.). The line of the *great fault* crosses the section in a deep morass very near the outcrop of the last-mentioned group (No. 9.); and at a very short distance the highly inclined beds of the *Scar limestone* rise into the bare hills, called the Clouds, and are continued (sometimes in a vertical position and sometimes contorted) to the rivulet where they are cut off by the greywacké chain.

It is possible that some of the groups above the *Scar limestone* may be concealed among the dislocated masses under the morass: but it is at least evident, that a portion of the *Scar limestone* has been broken off from the bottom of the carboniferous system, and lifted up to its present position over the edges of all the groups of the general section from No. 2. to No. 8. inclusive.

The first and second of these five transverse sections (Fig. 5. & 6.) connect the facts described in this paper with those already published by Mr. Phillips†; and the last three sections (Fig. 7. 8. & 9.) show the very complex nature of the movements along the line of *fault*, where it ranges close to the junction of the carboniferous and greywacké chains.—By combining these details with those given at the end of the preceding paper, "On the general Structure of the Cumbrian Mountains, &c. &c." ‡ we shall have a sufficiently minute account of the whole northern range of the great *Craven fault*, and of the structure of the neighbouring carboniferous chain.

§ 5. *Conclusion.*

1. I will not repeat what I have so recently stated on the changes of the carboniferous system in its range from Derbyshire to the valley of the Tweed§: but I may observe, that the region above described seems by its structure to form a natural link between the northern and southern portions of the chain.

* The hills are probably so called from the light grey colour of the dislocated rocks of *Scar limestone*.

† Geol. Trans., Second Series, vol. iii. pp. 12. and 9.

‡ *Supra*, p. 60.

§ See Anniversary Address, Feb. 18, 1831. Proceedings of the Geological Society, No. 20. p. 286—288.

The whole series of strata composing the mountains along the line of section may be divided into three great natural groups: 1st, The *Scar limestone.* 2nd, All the alternating subordinate groups (from No. 2. to No 12. inclusive), ending with the *great upper shale* over the *twelve-fathom limestone.* 3rd, All the various deposits (from No. 13. to No. 17. inclusive) associated with *millstone grit**.

The lowest of these groups is almost identical with the formation of mountain limestone at the base of the carboniferous series of Derbyshire and the Bristol Channel. The middle group has, on the contrary, little in common with the carboniferous series of Derbyshire, and, perhaps, still less with that of the Bristol Channel: but it conforms very nearly to a portion of the carboniferous system in the chain of Cross Fell. The third group appears in some form or other through the whole extent of the carboniferous chain; and, though by no means constant in its characters, undergoes perhaps less modification in its long range than either of the other two.

A fourth great group might include all the richest deposits of our northern, midland, and south-western coal-fields; and the analogies they present both in structure and position are obvious; but they belong not to the subjects considered in this paper.

In the North of England the deposit of mountain limestone was exposed to many interruptions, arising from drift, mud and sand, mixed with the wreck of numerous trees and plants. Upon such masses as these, encrinites and corals would obviously refuse to grow, till the incoherent sediment became compacted by calcareous matter, upon which they would again find an appropriate resting-place. The calcareous beds would then go on increasing till they were again interrupted by a new incursion of mud and sand. Effects like these were many times repeated.

In the valley of the Tweed these disturbing forces were in full action from the first commencement of the deposit of mountain limestone;—in Yorkshire (as appears from the previous details) they produced very considerable effects long before the complete development of the formation;—in Derbyshire, and in the south-western coal-fields, on the contrary, they produced but a small modification of the carboniferous system before the deposit of mountain limestone was completed.

I hope in a subsequent paper to describe several similar modifications of structure in the northern calcareous zone of the Cumbrian mountains.

2. Many of the coal-beds above described must have been deposited under

* The three longitudinal sections, fig. 2. 3. and 4, are coloured on this principle, the detailed subdivisions appearing only in fig. 1.

the waters of a sea of considerable depth; and I never saw any shells of decided freshwater genera in the carbonaceous shales alternating with the mountain limestone*; but these shales sometimes contain thin beds of marine shells, chiefly *productæ*. I am of course aware that freshwater shells occur abundantly in some of our rich coal-fields; and in such cases the deposits *may* have taken place in lakes, or more probably in shallow bays and estuaries. It is, perhaps, in very few instances necessary to consider them of purely lacustrine origin; especially when we remember, that in a part of the great Yorkshire coal-field (far above any of the groups represented in the preceding sections) there are beds abounding in pectens and ammonites.

3. Certain species of marine fossils abound in particular groups of the limestone strata, and so far become in some measure characteristic of them; but I am not sure that any one species is actually confined to one limestone group. Most of the fossils of the *Scar limestone* may be found, here and there, in the *twelve-fathom limestone*, and *vice versâ*†. Wherever there is a sudden change of mineral character, we may, however, remark an equally sudden change in the fossil species.

Thus, for example, very few of the corallines, encrinites, bivalves, &c. (abounding in the limestone) are found in the alternating beds of shale‡; and impressions of coal-plants hardly ever occur in the limestone groups, though they abound in the alternating groups of sandstone and shale. This distribution obviously originated, partly in the habits of the animals above-mentioned, and partly in the mechanical causes by which the beds themselves were produced.

4. The several groups of limestone, so remarkable above all the other strata for their regularity and continuity, were evidently the result of a slow tranquil deposit, assisted by the action of organic bodies; and most of the

* Some geologists have contended, not merely that all coal-beds are lacustrine, but that they once existed as turf bogs,—a supposition surely inapplicable to the carboniferous chains of Northumberland and Yorkshire. To bring such a theory into action, we must suppose that the chains in question were elevated, and again submerged under the ocean, at least as many times as there are beds of coal alternating with beds of encrinite limestone;—a most cumbrous, and, I think, an incredible hypothesis, which never could have been started by any one who had examined the coal-fields in the basin of the Tweed, or even the carboniferous chains of the North of England.

† I may, however, remark, that I have never seen trilobites, ammonites, orthoceratites, and perhaps some other rare fossils of the mountain limestone, in any part of the series above the great *Scar limestone*.

‡ The bands of *calliard* or *crow-limestone*, above described, may seem an exception to this rule; but the number of species they contain is, if I mistake not, very limited.

fossil remains subordinate to them have lived and died on the spots where they are now found. On the contrary, some of the other alternating strata have originated in an action decidedly mechanical, and their imbedded ligneous fossils have been drifted from a distance. Hence it is that these strata are in general much less regularly continuous than the groups of limestone. The observation must not, however, be strained too far; as some of the thin bands of coal above described are, on any hypothesis, of astonishing regularity and continuity*.

5. The bottom beds of each calcareous group are often impure, and contain very few traces of organic remains, and do not generally alternate to any considerable extent with shale and sandstone. We may also remark, that the corallines, zoophytes, &c. found in such positions are commonly of small size. At the top of each limestone group, on the contrary, the alternations of shale and sandstone are universal, and the fossils are numerous and full-grown. From all which it seems to follow—that each limestone group commenced at the beginning of a period of repose—that the marine animals which assisted its growth were at first few in number and ill-developed—that they gradually became vigorous and full-grown; and were at length destroyed only after repeated irruptions of mud and sand.

6. The valleys in the carboniferous chain, near the longitudinal sections, are not generally excavated on any lines of *fault*; and are, in the severest sense of the term, valleys of denudation. Yet the actual erosion on the ledges of solid rock at the numerous waterfalls (of which I have attempted to point out the origin), is in general so small as almost to demonstrate, that there must have been a great change in the distribution of the water-channels at some period, very recent when compared with that of the first elevation of the carboniferous chain, before the deposit of the new red sandstone.

* As an example of this, I may state that at Cross Pits, in the valley of Dent, the coal-seam under the *twelve-fathom limestone* is divided by a band of clay, half an inch thick, into two parts, with distinct mineral characters; and that the same coal-seam, with exactly the same subdivisions, has been found in the mountain on the opposite side of the valley, at the distance of three or four miles measured in a straight line. This seems to prove that a bed, not more than a fraction of an inch thick, was originally continuous through an area, probably several miles in diameter.

IV.—*Observations on some of the Strata between the Chalk and the Oxford Oolite, in the South-east of England.*

By WILLIAM HENRY FITTON, M.D., F.R.S. P.G.S., &c.

[Read June 15, 1827.]

(1.) IN a paper published in the Annals of Philosophy for November and December 1824*, I gave an account of the order and characters of the strata which occur beneath the chalk on the coast of part of the Isle of Wight and of Dorsetshire, and stated some reasons for supposing that a similar arrangement would be found to exist in the interior of England.

The principal objects of that paper were; *First*, to distinguish as a separate group, the series of strata now called the Lower Green-sand;—which had previously been confounded either with the beds containing green particles immediately below the chalk, or with the sandy and ferruginous strata conspicuously exhibited on the coast at Hastings, and then called "Iron-sand." *Secondly*, to indicate more clearly than had been done before, the peculiar characters of the group, which succeeds in a descending order to that just mentioned, and is remarkably distinguished by its fossils from the strata immediately in apposition with it, both above and below. For this latter group, which includes the Weald clay, the sand of Hastings, and the Purbeck limestone, and is well entitled to a separate denomination, I have adopted the name of "*Wealden*," proposed by Mr. Martin, in his valuable memoir on the West of Sussex†.

(2.) The objects of the inquiries which have produced the following pages were, to compare some portions of the series of strata between the chalk and the Oxford oolite, in different parts of the South-east of England; to ascertain the existence of the Wealden in the interior; and, if possible, to determine its boundaries.

* Annals of Philosophy; New Series, 1824, vol. viii. pp. 365, 458, &c.

† "Memoir on a Part of Western Sussex": 4to, London, 1828.

In stating the result of this investigation, I shall give a series of sections of the strata below the chalk, at places which I have myself examined *, beginning on the coast near Folkstone, and following the outline of the chalk thence to the sea on the N. West of Norfolk. The relative situation of these places is shown in the map annexed to this paper†. The intermediate country, in general, I have not examined in detail, and some points of importance I have never seen; but those who may have opportunities of continuing the inquiry, will find, I hope, no difficulty in connecting their observations with mine.

(3.) The series of strata about to be described extends from the Chalk down to the Oxford oolite or coral-rag, and is composed of alternating but irregularly distributed beds of Sand, Clay, and Stone.

Among the sandy strata, it is important to discriminate not only between the Lower green-sand and that of Hastings, but to distinguish both from a third group, consisting principally of sand abounding in green particles, which lies beneath the Portland stone.

Clay, of several varieties, occurs in all parts of this series; but three groups, constituting the Gault, the Weald-clay, and the Kimmeridge-clay, derive peculiar importance from their generally occupying valleys, or depressions, at the foot of the escarpments of the Chalk, the Lower green-sand, and the Portland stone, respectively, and thus producing conspicuous natural features in the tracts where this succession is observable.

The stone of the tracts under consideration is either limestone; indurated sand-rock; chert; or siliceous matter intimately mixed with carbonate of lime, in the form of grit,—which has commonly a concretional structure, and seems to pass into continuous beds only by the approach and ultimate union of the concretions.

But the most remarkable distinction, in the suite described in this paper, arises from the great difference of character in the organized remains which the principal groups include. The fossils of the chalk and green-sands and those of the Portland stone, are all marine, and the species numerous. But in the *Wealden*, between the lower green-sand and the Portland stone, although the fossils are abundant as to quantity, the species are comparatively few, and by far the greater part of them belongs to fresh water. The whole of the phenomena, in short, presented by this remarkable assemblage of beds, are such as to accord with the hypothesis of their having been deposited in fresh water communicating with the sea.

* Plates X. a, and X. b.

† Plate IX.—The detail, upon a larger scale, will appear in the new edition of Mr. Greenough's Geological Map of England.

(4.) Combining these sources of distinction, the following arrangement and subdivisions may be adopted, the nomenclature of which, however exposed to criticism, is now probably too well established to be changed without inconvenience*.

Chalk	*Upper.*	Fossils, marine: species numerous.
	Lower.	
	Marly.	
Green-sand	*Upper green-sand.*	
	Gault.	
	Lower green-sand.	
Wealden	*Weald-clay.*	Fossils, for the greater part, of fresh water: species few.
	Hastings sands.	
	Purbeck strata.	
Part of the Oolitic Series	*Portland stone.*	Fossils, marine: species numerous.
	Portland sand.	
	Kimmeridge and Weymouth clay and sand.	
	Oxford oolite (Coral rag).	

(5.) I proceed now to describe the Sections of these strata, beginning with the coast of Kent; and I shall connect with each section a list of such fossils as I have either found myself, or obtained on good authority from the places mentioned. The whole of the shells in these lists have been examined and named by Mr. James Sowerby, by whom also the drawings of the supposed new species were made, and the annexed engravings executed†. It is right to mention this explicitly, both that I may take the opportunity of expressing my acknowledgments for Mr. Sowerby's valuable and assiduous cooperation,—and that, being myself but very slightly acquainted with Conchology, I may place the portion of the following pages which relates to that subject on better authority than my own.

Vicinity of Folkstone, *Kent.*

(6.) The small map, (Plate VII. fig. 1.,) reduced from the Ordnance Survey, represents the country in the immediate neighbourhood of Folkstone and

* I have stated in another place (Annals of Philosophy, vol. viii. pp. 461, 462,) some objections to the employment of names for geological strata, which refer to characters not essentially connected with the structure or position of the objects to be designated. But the term green-sand, however faulty, besides the universal use of it in England, has been adopted both in Germany and France;—where, however, it may be regarded, in some measure, as free from the disadvantages of a significant name.

† Plates XI., *et seq.*

Sandgate,—the relative position of this tract being shown on the general map, (Plate IX.). The View (Plate VIII.), for which I am indebted to the kindness of my friend the Rev. J. D. Glennie of Sandgate, shows the actual appearance of the coast from Eastware Bay to Hythe; and the section (Plate X a. No. 1.) illustrates the succession of the strata, on a part of the shore which is not distinctly visible in the more direct view from the sea.

(7.) The chalk cliffs in the vicinity of Dover have been described in detail by the late Mr. William Phillips*; and the presence of the upper green-sand which had escaped the notice of Mr. Phillips, has been pointed out by Mr. De Basterot†. These, with Mr. Conybeare's more general description‡, and Mr. William Smith's coloured map of Kent, are the only modern geological illustrations of this part of England with which I am acquainted. But there is a publication of much earlier date,—Packe's "Chart of East Kent," with its explanatory memoir entitled ΑΓΚΟΓΡΑΦΙΑ, printed in 1743, which, though not strictly geological in its immediate object, points out very correctly the connexion between the external features and the disposition of the strata in the tract to which it relates, and contains such excellent views in physical geography as to demand especial notice in this place§.

(8.) As the chalk rises, in proceeding from Dover towards Folkstone, the upper beds disappear; the cliffs represented in the view and section consisting entirely of the lower members of that stratum. The rise of the marly chalk above the sea level occurs about a mile and a half to the east of the escarpment of Folkstone hill, and the place is well marked by the breaking out of a very copious and perennial spring, called "Lydden Spout," which issues from the top of these marly beds‖;—a situation probably corresponding to that of the springs which everywhere appear in the interior, along the foot of the chalk range. Near the "Spout" the cliff is about 450 feet high; the upper part consisting of very white chalk, with a bed of flint nodules, the rest of chalk without flints, gradually assuming a greyer hue as it descends. About the middle of the cliff a thick bed has acquired by exposure a rough and darker surface, by the aid of which it can be traced towards the west;

* Geol. Trans., First Series, vol. v. p. 16.

† Geol. Trans., Second Series, vol. ii. p. 334.

‡ Outlines of England and Wales, p. 119—184.

§ A more full account of this valuable work, which had been previously mentioned by Mr. Conybeare, will be found in a tract on the Progress of Geology in England, by the author of the present paper:—London and Edinburgh Philosophical Magazine for 1832, vol. i. p. 447, &c.

‖ A new species of Tornatella, named by Mr. Sowerby *elongata*, was found in the chalk marl at this place, by the Rev. G. E. Smith. See Plate XI. fig. 1.

and on the shore there are numerous detached masses, composed of round portions of grey marly chalk united by a yellowish-brown cement. The shore itself, at this place, is a firm floor of light bluish grey marl, the beds beneath being of a still darker hue. The vertical face of the cliff retires from the sea about 2000 paces west of Lydden Spout; and the intermediate shore, thence to Copt Point, is occupied by a mass of ruin, which has fallen from above, in consequence of the rise and erosion of the soft argillaceous beds beneath. The sudden transition to this ruinous under-cliff from the vertical face of chalk is very remarkable. A stratum abounding in green particles, intimately mixed with marl, appears at low water, in several detached places on the shore west of Lydden Spout, and is succeeded by the blue clay of the gault, which continues to Copt Point, where it rests upon the sand and grit of lower green-sand:—the prominence of the Point itself, and of the shore to the west of it, being evidently produced by the greater firmness and durability of the latter stratum.

The succession of the beds is best seen in the retiring portion of the shore, immediately on the north of Copt Point, (see Plate X a. No. 1.) A small outlier of the lowest chalk, with green-sand beneath it, is there exposed at the summit of the rounded hill on which stands the Martello Tower No. 3. Copt Point itself consists almost entirely of gault, which tops the low cliff thence to the village of Folkstone. The lower green-sand, rising gradually from the Point, occupies the whole cliff west of the village; and being continued without interruption, through Sandgate and in the heights above Hythe, its outcrop turns from the coast into the interior, at Aldington Corner. Finally, the Weald-clay, rising on the shore beneath Shorn Cliff, occupies the greater part of the heights and sloping ground on which the town of Hythe is placed, and extends about four miles farther to the west, where it gives place to the Hastings-sands.

In my obervations on this part of the coast, I shall confine myself to the beds below the chalk; referring for a detailed account of that stratum to Mr. W. Phillips's paper, already mentioned.

(9.) *Upper Green-sand.* The upper green-sand near Folkstone, is but a scanty representative of the formation, as it occurs in the Isle of Wight, Surrey, Western Sussex, and some other places in the interior; its total thickness probably not exceeding five-and-twenty or thirty feet, and the stony strata and concretions of chert being altogether wanting. Its rise upon the shore is concealed; and the stratum is first seen in its proper situation beneath the Martello Tower No. 2. A small outlying portion about fourteen feet in thickness, occurs beneath a cap of grey chalk marl about eight feet

thick, at the top of the hill on which the Tower No. 3. is placed*; and in this place the stratum consists of a soft marly sand, traversed in every direction by stem-like cylinders, which have within them cores of darker green matter. It also contains some irregular masses of a bright brown or orange hue; but the greater part is composed of grey calcareous marl, like the lowest chalk, so thickly interspersed with green particles as to exhibit only their colour.

The fossils which I found in this stratum were few in number, and indistinct: the only species that could be ascertained was the *Pecten orbicularis*†, one of the characteristic shells of the lower chalk and upper green-sand in Hampshire and Western Sussex.

(10.) The green matter, which abounds in this stratum near Wissant, on the opposite coast of France, has been examined by M. Berthier‡; who found it to consist principally of silica and protoxide of iron, with ten per cent. of potash. For the purpose of comparing the green-sands of different places and formations, my friend Dr. Turner, Professor of Chemistry in the London University, was good enough to examine some specimens from the upper and lower green-sands of Folkstone, of the Vale of Wardour, and the Boulonnois, and also particles of the same kind which abound in the sand and concretions beneath the Portland stone, in the Boulonnois, and in England. I subjoin the result of this examination§, whence it appears that in all these cases the

* See Plate VIII. and the Section, Plate X a. No. 1.

† Mineral Conchology, tab. 186.

‡ Cuvier and Brongniart, *Environs de Paris*, 2nd edit. 1822, p. 249. See also *Annales des Mines*, iv. 1819, p. 623.; and v. 1820, p. 197.

§ The following passages are transcribed from the notes with which Dr. Turner has favoured me upon this subject.

"The colouring matter of green-sand sometimes appears in the rock of its ordinary green tint, and sometimes in grains of so deep a green that they seem black. The former generally occurs in sand, or where the sandstone is porous, and in this state an ochreous appearance is often observed, due to the green particles being partially decomposed, and their iron having passed into a higher state of oxidation; whereas the black-looking grains are met with in highly calcareous sandstone, where the texture is too firm to admit of the percolation of water. From either kind of rock the green matter may be obtained by washing with water and subsidence, since the colouring matter subsides less readily than grains of quartz, and more readily than calcareous and argillaceous substances. For the purpose of analysis it is best procured from those calcareous sandstones where the cement predominates, as in the neighbourhood of Hythe and Folkstone in Kent. On reducing such samples to powder, washing away the finer particles with pure water, and separating any adhering carbonates by dilute muriatic acid, the colouring matter is left, mixed only with small grains of quartz. It then always appears in the form of earthy particles of a deep green tint.

"The green matter, when not previously weathered, is very feebly attacked by concentrated acids,

green matter is of the same nature. A slight examination of the green particles, which Sir John Herschel had previously the goodness to make for me, intimated the same results.

(11.) *Gault.* The rise of this stratum on the shore is also obscured by ruins of the superior beds; but it is visible in detached points, at low water, in Eastware Bay, and forms the greater part of the cliff at Copt Point, where many of the more beautiful specimens of the Gault fossils, seen in collections, have been obtained. It appears also below the outlier of the upper greensand already mentioned (Plate X a. No. 1.); and occupies nearly the whole of the grassy and ruinous cliff between the base of the Martello Tower No. 2, and the sea. Its total thickness is about 130 feet, and it may be divided into

even by the nitro-muriatic. It gives out water when heated, and becomes brown from its iron passing into the state of peroxide. As it has been supposed to owe its green colour to the presence of phosphoric acid, it was carefully examined, with the view of detecting that acid, if present. It was accordingly fused with carbonate of soda, the alkaline filtered solution neutralized by nitric acid, and evaporated to dryness, and the neutral solution tested by nitrate of silver and nitrate of lead. Of two samples of green-sand, thus examined, one was found to be quite free from phosphoric acid, and traces only were detected in the other. The former was also free from lime, and the latter contained but a small portion. It is hence obvious, that neither lime nor phosphoric acid are essential constituents of the colouring matter of green-sand, and their presence must be regarded as casual.

"In order to determine the chemical constitution of the colouring matter, I collected some green particles from the calcareous sand of Eastware-bay, near Folkstone, removing all foreign matter as far as possible, by washing with water and dilute acid. The only impurity which I could detect after this treatment consisted of small grains of quartz, the quantity of which varied in different samples.

"A portion of green particles thus purified, very free from oxidation, and dried at 212° Fahr. lost 7·0 per cent. of water when heated to redness.

"Another portion of the same sample was fused with carbonate of soda, and the earthy ingredients subsequently separated and weighed in the manner usual in such analyses.

"A third portion was heated with carbonate of baryta, and examined for potash, traces of which were readily found. According to the total result, the green particles consist of

		[M. Berthier's analysis of the green particles from near Havre gave the following proportions:—	
"Silica	48·5	Silica	50·0
Black Oxide of Iron	22·0	Protoxide of Iron	21·0
Alumina	17·0	Alumina	7·0
Magnesia	3·8		
Water	7·0	Water	11·0
Potash	traces	Potash	10·0
	"98·3		99·0.]

"It is superfluous to speculate on the precise atomic constitution of the green particles, since they were not obtained in a state of perfect purity. The ingredients which appear to be essential,

two portions. The upper part immediately succeeding the upper green-sand contains green particles; and thence, for some feet downwards, it is harsh and sandy. The lower portion consists of a smooth, uniform, very plastic clay, of a light bluish grey colour, much in request for the fabrication of tiles and common pottery. It is in this part of the cliff at Copt Point, that the perfect and beautifully iridescent Ammonites, Inocerami, Hamites, and other fossils, have been obtained. From the Point the stratum rises gradually to the west, forming the summit of the hill, about 108 feet in height, on the east of the town of Folkstone; and some traces of it also exist at the top of the next cliff, on which the church stands. From the coast the gault can be traced in a corresponding situation in the interior, along the foot of the chalk escarpment; its presence being everywhere indicated by a depression of the surface, and by the marshy aspect of the soil, which generally produces rushes and is strongly contrasted with that both of the chalk above, and of the lower green-sand beneath.

It is not improbable that in the Isle of Wight and some other situations where the fossils of the gault are rare, the upper and more sandy portion only of this stratum may exist. At Cheriton Tile-works near Folkstone, the workmen expressly state that it is the lower part only of their pits which affords the shells.

(12.) Throughout the gault, but chiefly in the inferior portion, concretions of iron pyrites are found, generally approaching to a globular or cylindrical figure, and of a radiated crystalline structure within, or in long thin vermicular rods, which at first sight might be taken for vegetable stems. On the opposite coast of France, near Wissant, the pyrites is so abundant in the gault as to have given origin, some years since, to a manufactory of sulphate of iron*; but near Folkstone the quantity is comparatively inconsiderable.

both from the quantity in which they occur, and their constancy in the colouring matter of green-sand from different localities, are silica, alumina, oxide of iron, magnesia, and water. I should hence consider the green matter as a hydrated silicate of alumina, magnesia, and black oxide of iron, and as being, in all probability, the true green earth, or earthy chlorite of mineralogists. The analyses of chlorite hitherto published are so discordant as to prove, either that different compounds have been examined under the same name, or that the specimens under examination were very impure. The essential ingredients, however, appear to have been the same as in the subject of my analysis.

"Though the foregoing description applies more immediately to the colouring matter of the green-sand from the vicinity of Folkstone, I have obtained similar results on examining that from Hythe and several other places. Indeed, from the examination of many samples of green-sand collected by Dr. Fitton from various localities in England and France, I believe the colouring matter to be precisely the same in all."

* See *Annales des Mines*, 1819, p. 623.

(13.) Other nodules and irregular masses are also found throughout this stratum, which resemble coprolite in their chemical composition, though no traces of animal structure are apparent in them. These are often associated with pyrites, and traversed by veins of that substance, as in septaria. Internally they are in general of a dark brownish hue, and the fracture is even or splintery, like that of some varieties of chert. The form of these nodules is sometimes very like that of coprolites; but though portions of shells are sometimes found within them, I have not detected any fragments of bone or scales of fishes. The surface of some of the detached masses is eroded, as if by worms; to the action of which, therefore, they were probably exposed before they were enveloped in the clay. In other cases they are of a very irregular figure, surrounding or incorporated with fossil remains, especially of Ammonites, the interior of which is filled with matter of the same kind.

Concretions of this description occur not only in the gault of different places, but are also numerous in the bottom of the lower green-sand at Atherfield in the Isle of Wight; and a mass found by Mr. Lyell in the crag at Southwold in Suffolk, which is mentioned by Dr. Buckland*, appears to have been of similar character. The concretions of the gault in Kent evidently agree with those of Havre and Wissant, analysed by M. Berthier, and found to contain about 57 per cent. of phosphate of lime, with a considerable portion also of carbonate of lime†. It can hardly be doubted that they are derived from the remains of animals, though no traces of bony texture are now perceptible; and it is not improbable that they may have been the contents of the intestines of marine animals, which fed upon each other, though not in all cases moulded into the form of coprolite.

The abundance of phosphate of lime, especially in submarine strata, will not appear surprising, when it is recollected that not only the bones, spiculæ and scales of fishes afford that substance in large quantities, but also the covering of the Echinodermata, and of crustaceous animals, in a smaller proportion ‡.

* Geological Transactions, Second Series, vol. iii. p. 234, note.

† Dr. Prout, soon after his examination of the Coprolites, of which Dr. Buckland has given an account in the Geological Transactions (Second Series, vol. iii. p. 237 &c.), was good enough to examine some of the concretions from the gault of Kent and the Vale of Wardour, and from Atherfield, and found them all to contain phosphate of lime, united with carbonate of lime and oxide of iron, in different proportions, the dark-coloured varieties containing the largest proportions of the phosphate. They all, likewise, yielded, more or less, the peculiar smell given out by coprolites when dissolved in muriatic acid. Dr. Turner has since examined other specimens, from the gault beneath Blanc-nez, and at Lottinghen on the east of the Lower Boulonnois, and finds them to indicate a similar chemical composition.

‡ Hatchett "On Shell and Bone, &c."; Philosophical Transactions 1799, p. 323, and 1800, p. 373.

(14.) The following is a list of the fossils of the gault in this neighbourhood, in my own collection, and in those of Mr. Hills, of Court-at-street near Lympne, of Mr. Sowerby, and some other of my friends. I take the present opportunity of expressing my obligation, especially to the Rev. Gerard E. Smith and Mr. Hills, for their kindness in supplying me with all the new species of their collections, many of which are figured in the plates annexed to this paper. Lord Greenock also has been so good as to allow me to have drawings taken from some specimens collected by himself.

List of Fossils from the GAULT, *in the vicinity of* FOLKSTONE, *Kent**.

Ammonites auritus. Fleur de Luce pits near Folkstone. F.
A. Benettiæ. Leacon Hill, about two miles S.W. of Charing, Kent. S.
A. Beudantii. (Brongniart; Env. de Paris, tab. vii. fig. 2.) Cheriton. F.
A.? circularis. Pl. XI. f. 20. Burham near Maidstone. So.
A. crenatus. Pl. XI. f. 22. Tile-works at Cheriton. F.
A. dentatus. (Syn. *A. serratus*, Parkinson.) Leacon Hill. S. Fleur de Luce. F.
A. inflatus. Folkstone. F.
A. lautus. Leacon Hill. S. Folkstone. Min. Conch.
A. minutus. Folkstone. Min. Conch.
A. proboscideus. Folkstone. Min. Conch.
A. Selliguinus. (Brongniart; Env. de Paris, tab. vii. f. 1.) (Syn. *A. lævigatus*? Min. Conch.) Cheriton, near Folkstone. F.
A. splendens. (Syn. *A. planus*? Mantell.) Leacon Hill. S. Tile-works, Cheriton. F.
A. subcristatus. (Brongniart; Env. de Paris, tab. vii. f. 10.) Fleur de Luce near Folkstone. F.
A. symmetricus. Pl. XI. f. 21 and 23. Clay-pits near the Fleur de Luce, Folkstone. F.
A. tuberculatus. Leacon Hill. S. Fleur de Luce pits, near Folkstone. F.
A. varicosus†. Folkstone. M. C.

* In this and the subsequent lists of fossils, the names are disposed in alphabetical order, for facility of reference. The new species are in Roman type, the rest in Italics. A systematic list of all the genera and species of the several lists will be given at the close of these pages.

In the statement of localities, the capital letters after the names of places denote the persons to whose authority the occurrence of the several species is referred; H. signifying Mr. Hills, of Court-at-street near Lympne; S., the Rev. G. E. Smith, A.M.; So., Mr. Sowerby; G., Henry H. Goodhall, Esq.; F., the Author of this paper. The letters M. C., or Min. Conch., denote the Mineral Conchology of Messrs. Sowerby; Geol. Soc., the Museum of the Geological Society.

† Mr. Parkinson has mentioned other species of Ammonites; *A. ornatus*, from Folkstone and Cambridge, *A. pansus*, from Folkstone and West Malling, Kent (Geol. Trans., First Series, vol. v. pp. 57 and 58). The *A. serratus* of Parkinson is *A. dentatus* of Sowerby.

Auricula inflata. Pl. XI. f. 11. Copt Point? S.

Belemnites attenuatus. Leacon Hill. S. Near Folkstone. F.

B. minimus. (Syn. *B. Listeri.*) Folkstone. F.

Cardium? decussatum. Copt Point. S.

C. (species doubtful). Indistinct specimens, apparently different from *C. decussatum.*

Caryophyllæa. Folkstone. F.

Corbula striatula. Folkstone. Min. Conch.

Corystes? Mantell, Sussex. Pl. 29. fig. 13. Near Folkstone. S.

Cytheræa parva. (Syn. *Venus parva*; M. C.) Eastware Bay and Leacon Hill. S.

Dentalium ellipticum. Copt Point. S.

Exogyra conica. Near Hythe. H.

Gastrochæna (species doubtful). Found in perforations of dicotyledonous wood. East of Folkstone. S. and F.

Hamites aculeatus. Pl. XII. f. 4. Copt Point. H. and S.

The Rev. G. E. Smith's observations on the new points in the structure of this genus will be found hereafter, with Mr. Sowerby's description of the species figured in the Plates annexed to this paper. The figures in Pl. XII. are from drawings by Mr. Smith.

H. armatus. Near Folkstone. F.

H. attenuatus. Pl. XII. f. 3. Copt Point.

H. compressus. Fleur de Luce near Folkstone. F.

H. gibbosus. Fleur de Luce near Folkstone. F.

H. elegans. (Parkinson, Geol. Trans. v. p. 58.) Folkstone. S.

H. intermedius. Leacon Hill, and Fleur de Luce pits. F.

H. maximus. Leacon Hill. S. Fleur de Luce. F.

H nodosus. Near Hythe. H.

H. rotundus. Pl. XII. f. 1 & 2. Copt Point. S.

H. tenuis. Near Folkstone. F.

Inoceramus concentricus. Beautiful specimens of *I. concentricus* and *sulcatus*, with various Ammonites, retaining the pearly lustre of the shell, are found in great numbers about the middle of the cliff at Copt Point. F. Folkstone; W. Malling, Kent; and Cambridge: (Parkinson, Geol. Trans. v. p. 57, 58.) Also at Leacon Hill. S.

I. Cripsii? Mantell, Geol. Sussex, Pl. 27. f. 11. Near Sandgate.

I. sulcatus. Folkstone; W. Malling, Kent; and Cambridge: Parkinson.

Modiola bella. Pl. XI. f. 9. Near Hythe. (Lower Green-sand?) H. and F.

Murex calcar. Folkstone? F.

Natica canaliculata. (Syn. *Ampullaria canaliculata*, Mantell.) Pl. XI. f. 12. Near Folkstone. S. and F. The specimen *a*, *b* is filled with brownish (coprolitic?) phosphate of lime.

Nucula bivirgata. Pl. XI. f. 8. Eastware Bay. H. and G. Leacon Hill. S.

N. ovata. Mant., Geol. Sussex, Pl. 19. f. 26. 27. Folkstone. Mantell.

N. pectinata. Copt Point and Leacon Hill. S. Fleur de Luce pits and Cheriton. F. W. Malling, Kent; and Cambridge: (Parkinson, Geol. Trans. v. p. 59.)

Nucula? undulata. Copt Point? S.
Ostrea macroptera? Fleur de Luce near Folkstone. M. C. and F.
Panopæa plicata. (*Mya plicata*, Min. Conch.) Near Folkstone. M. C.
Pentacrinus. Pl. XI. f. 4. Copt Point. H.
Plagiostoma elongatum. Folkstone. Specimens have been found $1\frac{1}{4}$ in. wide, $\frac{3}{4}$ in. deep, and $\frac{1}{2}$ in. thick. G.
Pleurotomaria Gibsii. (*Trochus Gibsii* of Min. Conch.) Copt Point and Leacon Hill. S.
Plicatula pectinoides. East of Folkstone. S.?
Pollicipes lævis. Pl. XI. f. 5. Copt Point, Folkstone. H.; with the following species:—
P. rigidus. Pl. XI. f. 6*. Copt Point. H.
P. unguis. Pl. XI. f. 5*. Copt Point. H.
Pyrula?† Smithii. Pl. XI. f. 15. Copt Point. S.
Rostellaria buccinoides. Pl. XI. f. 17. Eastware Bay. G.
R. calcarata. Near Folkstone. S.
R. carinata. Pl. XI. f. 19. Eastware Bay. S.
R. elongata. Pl. XI. f. 16. Copt Point, Folkstone. H.
R. marginata. Pl. XI. f. 18. Copt Point. H.
R. Parkinsonii. Copt Point and Leacon Hill. S.
Serpula antiquata. Near Beachborough, Folkstone. M. C. (Upper Green-sand?)
S. articulata. Folkstone. M. C.
S. rustica. Eastware Bay. M. C. (Upper Green-sand?)
Solarium conoideum. (Min. Conch.) Pl. XI. f. 14. Near Folkstone. S. and F.
S. ornatum. Pl. XI. f. 13. Fleur de Luce near Folkstone. S. and F.
Spatangus argillaceus. (Phillips, Geol. of Yorkshire, Pl. II. f. 4.) East of Folkstone.
Teredo? In fossil Dicotyledonous wood, Leacon Hill. S. Folkstone, and Cambridge: (Parkinson, Geol. Trans. v. p. 58.)
Terebratula biplicata. Folkstone (in gault?). S.
T. sella. Near Folkstone (in gault?). S.
T. sulcata. Folkstone, and Cambridge: (Parkinson, Geol. Trans. v. p. 59.)
Tornatella? affinis. Plate XVIII. fig. 9. Eastware Bay. S.
Trochus Gibsii? See *Pleurotomaria Gibsii.*
Turbinolia Kœnigii. Leacon Hill. Very abundant. S.
Turritella (species doubtful). Folkstone. S.
Venericardia tenuicosta. Pl. XI. f. 7*. Eastware Bay. H.
Venus parva. See *Cytheræa.*
V.? tenera. Pl. XI. f. 7. Copt Point near Folkstone. H.

† In naming this genus, and some others mentioned in this paper, respecting which doubts may be entertained, Mr. Sowerby appears to have been influenced by a desire to produce all the information which the specimens could afford, conceiving that even if the names be erroneous, the figures may still have some value as objects of future comparison.

Wood, dicotyledonous. East of Folkstone. Perforated by Gastrochæna; near Folkstone. S. Sometimes surrounded with pyrites. Mr. Parkinson states that "fossil "wood occurs plentifully in the marl (gault) of Folkstone; lying chiefly at the "bottom of the stratum, on the green-sand." Geol. Trans. v. p. 59.

(15.) *Lower Green-sand.*—The uniform surface of this stratum, extensively shooting out beyond the chalk, forms a conspicuous feature of the country, which is well seen from the ascent of Folkstone Hill on the road to Dover*. The analogy in this respect to the appearance of the sands at the Blackdown Hills in Devonshire, is obvious and striking. The Bagshot sands, above the chalk in Surrey, also exhibit long and uniform platforms, the section of which presents a linear and almost horizontal top, with a rapid escarpment at both extremities.

(16.) One of the principal circumstances in the internal structure of the Lower Green-sand at Folkstone, is the distinctness with which it is divided into three groups; and this subdivision probably occurs wherever the formation is fully developed in the South-east of England. It is clearly seen in Surrey; I have evidence from Mr. Martin of its existence in the West of Sussex; Mr. Lonsdale believes it to hold also near Devizes in Wiltshire; and though I did not become acquainted with it till after I had examined the Isle of Wight, I have little doubt that it will be found there also.

a. The first of these subdivisions may be characterized as consisting principally of sand, white, yellowish, or ferruginous, with concretions of limestone and of chert, frequently in false stratification. It forms commonly a flat, but sometimes an irregular hilly surface, rising from the valley of the gault, and bearing a dry, barren soil.

b. The second member abounds in green matter, is retentive of moisture, and contains comparatively little stone: it occupies a flat and marshy tract, between the first and third divisions.

c. The third and lowest member contains a greater proportion of calcareous matter, and includes some of the principal beds of stone bearing the name of "Kentish Rag"; which commonly form a prominent ridge at its outcrop, adjoining the valley of the Weald†.

* From Folkstone Hill the ridge of Fairlight Down, near Hastings, is a very striking object: its range is evidently parallel to that of the chalk outcrop, as might be expected in the axis of elevation of the tract by which it is surrounded.

† In Mr. William Smith's Geological Map of Kent, two ranges are indicated, by darker colours, in the tract between the coast and Maidstone; one running parallel to the chalk, from Sandgate through Ashford and Bursted to Penenden-Heath, on the N.E. of Maidstone; the lower, less regularly, from Hythe along the verge of the Weald Clay. These lines, I have no doubt, indicate a subdivision like that mentioned in the text: but in the explanatory table of the map, the stone of the tract thus coloured is said to be the Portland-rock.

The situation and relative space occupied by these subdivisions near Folkstone, are shown in the small Map, Plate VII. fig. 1., and in the View, Plate VIII.

(17.) *a.* The uppermost subdivision is about seventy feet thick. It rises upon the shore on the west of Eastware Bay; and some of the firm siliceous beds which it includes near the top, coming up from the sea a little to the east of Copt Point, are continued in the cliff thence to the west of Sandgate; between which place and Folkstone distinct sections are disclosed. The greater part of the country from Folkstone, through Cheriton, to Newington is occupied by this bed, and the heights of Dibgate and Sine Farm, where it finally disappears, are capped with it.

(18.) Where the sand emerges from beneath the Gault, it is often loose, and of a white or buff colour; but at the immediate junction there occurs, in many places, a course, from six inches to a foot in thickness, of concretions of pyrites, often investing fragments of silicified coniferous wood, of a dark brown colour. The composition of this bed resembles, in several respects, that of the Blackdown sands in Devonshire, the stone which it includes consisting principally of siliceous spongy concretions, like the whetstone of that place. The most instructive specimens are to be found in the loose decomposed masses on the shore. In the vertical faces of the cliffs, the surface exposed by fracture and falling away is at first clean and uniform, no traces of the stratification appearing; but after a time the sand crumbles from the surface, while the stony portions remaining fixed, become prominent.

The whole of these cliffs consists, in fact, of sand and conglomerates more or less firm, produced by the agglutination of the loose materials which formed the original submarine deposit. The strata vary in texture and composition, from the state of sand to that of very hard limestone or chert, of various shades of grey and brown; the latter passing into chalcedony, with which the cavities are sometimes coated*. The transition from the sand into compact stone is sometimes very rapid; in other specimens the gradations are almost insensible.

(19.) The principal components of these conglomerates are the following:

1. Quartz, in rounded fragments, from the bulk of a large pea to the minutest visible size, of several shades of grey and white, varying from transparent to nearly opake, and in some instances passing into chalcedony.

2. Small, worn fragments of quartzose jasper, red, or greenish; with flat surfaces, in some cases, indicating stratification.

* It is remarkable, that notwithstanding the abundance of siliceous matter in the concretions near Folkstone, few or none of the petrifactions are formed of it; while at Blackdown in Devonshire most of the shells in this formation are casts in chalcedony.

3. Fragments, frequently much larger than those above mentioned, of very compact, dark brown, black, or grey flinty slate. Sometimes the appearance of these fragments is internally that of hornstone, approaching to jasper.

4. Fragments, often angular, or slightly rounded, of schistose granular quartz, or sandstone, interspersed with very minute particles of mica; not effervescent; its colours varying from smoke grey to greenish.

5. Near Ashford, in the ferruginous sand at the top of the formation, fragments are found of brown hematitic iron ore; but much less abundantly than in the corresponding part of the section at Redcliff, near Sandown, in the Isle of Wight, and at other places.

6. Near the top of the sands, in the blocks of decomposed stone, upon the shore, lumps are found, from the size of a walnut downwards, of a dark brown substance, externally spongy, and of irregular surface, and within having the fracture and appearance of the phosphate of lime described in Section (13)*. In these brown masses are also some grains of quartz, and small portions of shell. This occurrence of phosphate of lime, both in the gault and at the upper part of the lower green-sand, is an additional proof of the continuity of their deposition.

(20.) The stone of the more uniform beds ("Kentish-rag,") has great variety of characters, from those of a granular or sparry compound to compact limestone, some specimens of which might be taken for that of older formations. In many cases, the calcareous cement is so crystalline, that light is reflected continuously from extensive surfaces, although the face of the fracture is thickly set with small pebbles of quartz; in other cases the stone is a dense conglomerate, composed of quartz grains with a small proportion only of the cement. All the varieties contain disseminated grains of the green matter above described in section (10); which is frequently so abundant as to give its colour to the stone. In many of the rolled fragments on the shore near Folkstone, this constitutes more than half the compound, the remainder being decomposed carbonate of lime, inclosing grains of quartz and flinty slate. In the more advanced state of decomposition, the mass has the appearance of mortar; and, in most cases, the stone effervesces copiously with acids, the green particles remaining undissolved.

The chert of this upper stratum is frequently of a dark grey colour, and

* The specimens here referred to were sent me from the shore immediately on the west of Folkstone, by my friend the Rev. J. D. Glennie; but there can be no doubt of their having fallen from the adjacent cliffs. Among the darker masses mentioned in the text were portions of the claws of an Astacus. On the shore hereabouts plicated Terebratulæ were found in nodules of arsenical pyrites.

very like chalk flint. In some specimens, this dark variety adjoins, with scarcely any gradation, a light grey, or white siliceous agglomerate, in which the original sandy structure is still discernible; while in the adjacent darker chert the fracture is flat-conchoidal and splintery, with the glimmering lustre of hornstone, all trace of the grains having disappeared;—as if a sand of wax had been consolidated by gentle softening, in a heat not sufficient for its liquefaction. In its passage to chalcedony, the siliceous matter often assumes a white colour, the aspect being nearly that of porcelain, and it becomes translucent when moistened.

(21.) A section of the upper part of this member (*a*) of the lower green-sand, in the cliff about midway between Folkstone and Copt Point, was as follows:

Top of the Lower Green-sand.

	Feet.	Inches.
Bluish grey clay (*Gault*), a few feet in thickness, at the top of the cliff: then—		
1. At the junction of the clay and sand is a bed consisting of pyrites in lumps, more or less decomposed; about	1	0
2. Grey quartzose sand, with numerous green particles	4	0
3. Sand, in which lines of false stratification are conspicuous	1	6
4. Similar, but coarser sand	2	6
5. Sand, yellowish, slightly concreted, irregular in thickness; much more solid in the eastern part of the cliff; about	3	0
6. Sand	2	0
7. Irregular siliceous concretions	0	9
8. Sand, nearly as above, with a few dispersed concretions	3	0
9. Irregular concretions, like No. 7	1	6
10. Sand, with a few scattered concretions	3	0
11. Irregular concretions, in sand; more dispersed	2	0
12. Sand, as above	4	0
13. Concretions	0	3 to 6
14. Sand; as above, but finer; about	5	0
15. About four courses of concretions, with sand between	3	6
16. Sand;—to the foot of the cliff	4	0
Total; about	38	0*

The concretions of Numbers 5, 7, 9, 11, 13, 15, consist of siliceous spongy stone, like the whetstone of Devonshire, varying from a loose friable mass, to the consistency of chert. In many instances the surface has the form of cylindrical stems.

* The height of the cliff at this place is really not more than thirty feet; but the *proportions* are nearly as above given.

(22.) In another section of this part of the stratum, at one of the quarries about midway between Risborough and the east of Sandgate*, the detail was thus:

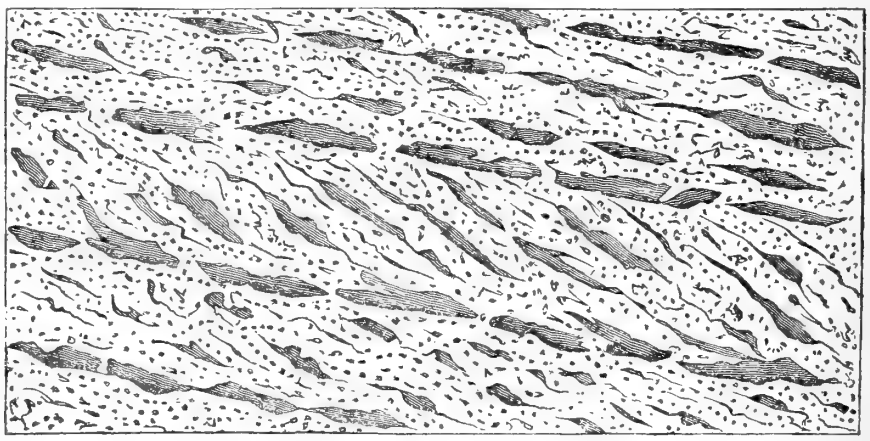
	Feet.	Inch.	Feet.	Inch.
Surface of the hill.				
1. A group, consisting of alternate courses of sand and irregular siliceous concretions:—				
a. Sand, with a few interspersed concretions	0	3		
b. Stone, in irregular spongiform concretions, including fragments of Oysters or Gryphites, and passing into grey, compact chert, which in some instances graduates into chalcedony;—retaining, however, traces of the original sandy structure. The concretions include also minute fragments of calcareous matter, so that the surface effervesces in detached points; about	0	2		
c. Sand; loose, somewhat coarse, consisting principally of grains of quartz	0	6	about 3	0
d. Stone; in loose spongy concretions, white, opake, and in some places more compact within, like chalcedony; not effervescent.	0	4		
e. Sand; coarse, dark brown, not effervescent; a great part consisting of grains of translucent quartz	0	6		
f. Stone; in roundish, flattened concretions. A conglomerate of granules of quartz, with some portions of flinty slate, and dark green specks, cemented by sparry carbonate of lime: from 2 inches to	0	8		
g. Sand; dark greenish grey, not effervescent, including casts of Ammonites in pyrites	0	4		
h. Stone	0	2		
i. Sand; dark greenish grey, gritty, not effervescent	0	4		
2. A bed of siliceous and porous concretions, nearly continuous; very like the whetstone of Blackdown; not effervescent			0	2 to 4
3. Beds of sand, partially concreted, somewhat coarse, soft, effervescing copiously, and including concretions of cherty stone. The false stratification of this part of the cliff is very conspicuous			3	0
4. Stone, alternating with sand: thus:—				
a. Stone, in somewhat compact concretions, oblique to the general stratification, including cylindrical portions, like the stems of Siphonaria; the greater part siliceous, white and opake, but effervescing in detached spots; about	0	9		
b. Sand, greenish grey, effervescing copiously	0	6	about 4	0
c. Stone, in loose, spongy, irregular concretions	0	9		
d. Sand, loose, greenish grey, effervescent	0	6		
e. Stone, in spongiform concretions, like 1. *b.* above, passing into chert	0	4		
f. Sand, like *d.*	0	9		
g. Stone, in spongy concretions; as at Blackdown	0	4		

* See the Map, Pl. VII. fig. 1.

5. Sand, with concretions; greenish grey, uniform, not effervescent. At the bottom of this bed is a course of concreted sand passing into stone, with seams oblique to the general stratification. The stone is in some places opake and white, like chalcedony, including however minute dark green particles: the looser pieces are spongy, like the Blackdown whetstone..	about 3 0
6. Sand and stone: thus:—	
a. Sand, resembling that of No. 5, but of darker colour	
b. Stone. A dark grey, compact, fine-grained, conglomerate of calcareous spar and grains of quartz, in some places traversed by thin veins of spar	about 3 0
c. Sand, resembling *a*, uniform, not effervescing.....	
d. Stone; a compact conglomerate, including small portions of dark flinty slate.....	
Total .... about	16 0

In another quarry, immediately beneath this one, the composition was apparently the same; but the beds of chert were more numerous.

(22.) The false stratification above alluded to, or the subdivision of the beds by lines oblique to the general course of the stratification, is a prominent circumstance in the upper part of the lower green-sand in this neighbourhood. It is observable in several places on the road from Hythe to London; and was very well exhibited in the sides of the road through the hill between Sandgate and Folkstone, where the sketch subjoined was taken.



In the beds, of which a portion is here represented, not only the lines of division, but the concretions within the strata exhibit the oblique arrangement; and in some instances, the larger cherty masses, the general direction of which is that of the prevailing stratification, send out offsets in the direction of the false strata, as expressed in the sketch. There is no appearance of

variation in the circumstances under which the different strata were deposited, although some of those traversed by the lines above described alternate with others, in which no traces of them, or scarcely any, are to be seen.

(23.) The concretional masses described in the preceding sections give rise to some questions of great interest in geology. There can be no doubt that all these strata were originally deposited in the state of sand and gravel; but in the quarries of East Kent all stages of gradation can be perceived, from distinctly separated concretions of stone*, to others so nearly uninterrupted, that the next step into perfect continuity can be easily conceived. The sands below the Portland-stone the coral-rag and the inferior oolite, afford examples of the same character: and in all these cases the concretions must have been formed after the deposition of the sand which includes them, and probably beneath a great depth of compacted materials. In such a mass, shut off from the free access of air and change of temperature, there is no obvious reason for disturbance of the affinities which maintained the original form of the components, except the decomposition of the animal and vegetable remains diffused among the stony substances; yet here we have not only solid limestone, where nothing but loose sand and gravel were before, but firm siliceous concretions, pervading, and so identified with, the separated particles of the quartzose sand, that the whole is nearly homogeneous. If the decomposition of the organized substances, continually acting throughout very long periods of time, be not sufficient to produce the whole of these effects, perhaps it may be supposed that electricity is the cause which sets free the elements, and disposes them to combine anew†.

(24.) The second, or middle subdivision (*b*.) of the lower green-sand, first

* Concretions nearly globular occur, in the uppermost yellowish sands, at Parkhouse, near Folkstone.

† In preparing nitric acid in a chemical laboratory where I was attending some years ago, the glass retort broke towards the close of the operation, and a quantity of the concentrated solution of bisulphate of potash oozed out through a very fine crack into the surrounding sand. On removing the retort some time afterwards, a large part of the sand was found to be agglomerated into beautiful concretional masses, like bunches of grapes, the greater portion of which, of course, was sand, and the cementing substance the crystallized salt. The masses of gravel frequently found cemented by carbonate of lime, or of iron, in consequence of the escape of the carbonic acid which had held those substances in solution, is an example of another mode of concretion. In the first of these two cases the loss of heat, in the latter the escape of a chemical solvent, has obviously been the cause of the consolidation. But the case mentioned in the text is distinct from both.

Dr. Turner justly remarks, respecting substances usually considered as insoluble, that "although "the weight of such bodies is not perceptibly diminished by trials conducted in the laboratory, "during a short interval of time, and with small quantities of water, the effect of the same opera-

appears upon the shore on the west of Folkstone, at a point immediately beneath the church*, which is well marked by the breaking out of a spring. It is there conformable to the strata described in the preceding sections, and the whole of it has risen to some feet above the sea, on the east of Sandgate, where rocks of the subjacent group (*c.*) make their appearance on the shore. This second stratum forms the middle of the cliff above and behind the village of Sandgate, but thins off and disappears in the heights on the west of Nail-Down, where some outlying portions of the superior sand (*a.*) cap the summit of the hills. Its thickness appears to be from 70 to 100 feet: it abounds in green matter, and in some places in pyrites; from the presence of which substances (though in what manner is not obvious), or perhaps of some portions of clay, it acquires a retentive property; so that the soil over it is marshy, and ponds are frequent upon its surface. The tracts, therefore, which it occupies, have in some cases in the interior been erroneously supposed to belong to one of the beds of clay subjacent to the green-sand.

(25.) The boundaries of this middle bed, where it is disclosed by the streams having cut through the incumbent sands, are sufficiently indicated on the map. In following up the streams towards Inbrook and Frogwell, the contrast of the two strata is very conspicuous, the junction of this retentive middle group with the sands above being indicated by the breaking out of springs†; and a line drawn through the heads of the streamlets thus arising would be throughout at distances from the outcrop of the chalk nearly proportioned to the inclination of the strata.

(26.) The presence of this stratum occasions frequent falls of the incumbent sand beds, and has given origin to an under-cliff covered with vegetation, which extends from Folkstone to Sandgate. The sections therefore are obscured; but enough is visible to prove that it contains no prominent beds of stone, and that concretions are comparatively rare in it. Near its junction with the stony strata beneath, the consolidated sand affords several characteristic fossils; and about the middle of the heights over Sandgate‡, a line of ferruginous nodules has been found, inclosing fossils, like those of

" tion, as performed on the great scale in the mineral kingdom, during hundreds and thousands of " years, and with unlimited quantities of the menstruum, might be, and doubtless was, very dif- " ferent."—'Report of a Lecture on the Chemistry of Geology'; Lond. and Ed. Philosophical Magazine, 1833, vol. iii. p. 24.

* See the View, Plate VIII.

† It is not impossible that the site here mentioned may correspond to that of the Sandrock spring, in the Isle of Wight. A ferruginous spring, I was informed, does exist in the vicinity of Sandgate.

‡ In the grounds of Encombe, the seat of Mr. Dawkins. The place is indicated in Plate VIII.

Shanklin Chine in the Isle of Wight, and of Parham Park in Western Sussex.

(27.) The following sections, at a prominent point of the cliff, between Sandgate and Folkstone, include a portion of the first or upper member of the lower green-sand (*a.*), with the upper part of the middle stratum (*b.*).

Section of the Cliff between Folkstone and Sandgate.

(*a.*)

	Feet.	In.	Feet.	In.
1. Sand, with numerous courses of concretional stone, and traces of false stratification			about 10	0
2. A prominent group of sand and concretional stone;				
a. Stone. Firm, uniform, fine-grained, sparry, conglomerate, with minute, dark green particles. Some of the blocks on the shore, apparently fallen from this bed, consist of close-grained splintery limestone, somewhat sparry, including minute dark grains, disseminated in small proportion. They afford excellent specimens of the 'Kentish 'rag'	about 2	0	6 to 8	0
b. Sand, including concretions of chert; about	2	0		
c. Stone. Loosely concreted conglomerate, including shells, effervescing copiously; when decomposed looks like mortar	about 2	0		
3. Several courses of sand and concretional stone;				
a. Sand		?		
b. Thin course of concretional cherty stone, nearly continuous. The chert passes into chalcedony, and the spongy portions include shells	0 to 0	4 6		
c. Sand, with spongy concretional stone, approaching to that of Blackdown, but looser		?	altogether about 8	0
d. Sand		?		
e. A bed of siliceous masses, like the stems of Siphoniæ; about	0	6		
f. Sand		?		
g. Greenish grey concretional stone, in irregular masses		?		
	about		25 feet.	

(*b.*)

4. Greenish grey and yellow sand, including various concretions;				
a. Sand, about 5 or	6	0		
b. Very large concretional nodules, consisting of greenish sand, slightly consolidated		?	between 40 and 50	0
c. Sand, without prominent beds of stone; about	40	0		
Total			from 70 to 80 feet.	

Beneath is the plateau of the under-cliff, supporting ponds, and producing

rushes; probably thirty-five to forty feet in thickness, down to the sea:—of part of which the section is as follows:—

(*b.*)	Feet.	In.
1. Yellow sand; face nearly vertical, from a recent fall	4 to 6	0 0
2. Dark smoke-grey, crumbling, sandy clay, or cohesive sand, greenish at the bottom	about 8	0
3. A band of firmer green-sand, splitting horizontally into very thin layers, from the interposition of lighter-coloured sand, which seems to occupy the place of thin cylindrical stems or twigs. In this bed the hammer leaves a mark of a vivid green colour, but the general hue is dark greenish grey. It consists of very minute particles of quartz, intimately mixed with a large proportion of the silicate of iron, soft, and of a full green colour; not effervescent, except in minute spots. The gradations from this compound through all shades of colour and consistence, to brown, and even yellow, sand, are imperceptible	about 0	9
4. Dark greenish grey sand, apparently continuous with, and passing into, the tenacious matter of the lower beach	about 6	0
Total, about	20	feet.

The bottom of this group is concealed by the loose gravel of the beach.

(28.) A striking characteristic of the middle group (*b.*) is the great diversity of hue and consistency which it assumes under different circumstances. The colour when dry is frequently a rusty yellow;—but in other states, connected perhaps with the different degrees of oxidation of the iron, or with the decomposition of the pyrites, which it frequently contains, it is of a dark greenish hue, and passes rapidly from the consistency of loose dry sand to a tough cohesive mass. In these respects it resembles the middle portion of the cliffs in the Isle of Wight.

Near the bottom, immediately above the stone of the group (*c.*), this middle stratum consists of a dull greenish, sandy, and mud-like substance, apparently a mixture of clay with the green particles, which becomes plastic, and almost black in water. In these dark sands, near Seabrook, are decomposed fragments of petrified coniferous wood*.

(29.) The third group (*c.*) of the Lower green-sand first rises on the shore

* The Rev. G. E. Smith informs me, from Sir John Tylden, that the high tides in the spring of 1833 having laid bare the strata, the latter had an opportunity of observing the lowest bed, of what he not unaptly calls the 'Blue Division,' on the shore between Shorn Cliff and the village of Sandgate. "It is," he says; "very marly, and includes a great quantity of wood and pyrites, "and in places resembles the gault of Eastware Bay." The "very marly" beds may probably be the equivalent of the Fuller's earth of Surrey, &c., which has not, that I know of, been distinctly seen in this part of Kent.

beneath low-water mark, about midway between Folkstone and Sandgate: and the projection of the land to the south, immediately on the west of Folkstone, and thence to Sandgate, appears to have been produced by the firmness of the barrier which this solid base of the cliff opposes to the sea. It becomes visible again above high-water mark, about a furlong west of Sandgate, is seen in detached places along the shore under that village, and rising above the beach at Shorn Cliff, beneath which place the Weald clay makes its appearance, can be traced readily in the heights to the westward, being opened in several places for stone.

(30.) From Hythe this group of strata forms the escarpment of the cliff, as far as Aldington Corner, where it turns inland, towards the north-west; and thence, along the valley of the Weald clay, a similar barrier of stone forms the boundary of the green-sand formation. The line of coast, from Copt Point to near Aldington, not being exactly parallel either to the *strike**, or to the dip, but oblique, the inclination of the stone beds appears in the coast section to be less than the truth; and where, as at Lympne, between Hythe and Aldington, the escarpment becomes parallel to the strike, the strata appear to be horizontal.

In the progress of this lower ridge to the north-west, from near Aldington Corner to a hill above Singleton Green on the south of Great Chart, there is a remarkable interruption of the escarpment, where the line of heights retreats towards the north; so that the streams which take the opposite directions,—westward to supply the Medway, and northward to join the branches of the Stour which pass through Ashford, are there nearly united†. An obvious explanation of this effect might be, that the concretions of stone were wanting in this portion of the strata, so that the sands thus unsupported were more easily carried away.

(31.) The relations of this lowest bed to the remaining groups are very well displayed in the ground between Seabrook and Saltwood, especially in the road leading from Dibgate to Sine Farm, and thence to Hythe. On the

* I adopt this term, suggested by Professor Sedgwick, to express the course of the intersection of strata with the plane of the horizon, in preference to *direction*, commonly employed;—the latter term being ambiguous in its application.

† In Packe's "Map of East Kent" above referred to, this is called "a Grand Inosculation," and is thus described: "From this quarry of rag, east of Chart Magna, to the other quarry of the "same, west of Aldington, the Weald of Kent and the Ashford Vale meet, and are upon very "gentle ascents towards each other, inosculated by the extremities of the valleys insensibly into "one another, the stone hills receding to Ashford, Wilsborough, Sevington and Mersham, the soil "of both being the same deep clay; and these stone hills are the true philosophical boundaries of "both these regions."

west of Sine Farm the upper stratum is no longer found, the middle and sloping portion of those hills consisting of the greener beds (*b.*), with a cap of the upper sands (*a.*) on the top. An outlier of the middle stratum resting upon the lowest (*c.*), forms the summit of the ground between Saltwood Castle and Hythe.

Springs break out both from the top of the Weald clay below this group of stone, and from the cohesive sandy clay above it; a considerable thickness of the latter being interposed between these stone beds and the sands which cap Sine Farm and Nail-Down Hills.

(32.) Though in a general view the rise of this and the other members of the lower green-sand accords with that of the chalk, the dip being at a small angle to the east of north, the beds of stone which are uncovered at low tides, upon the shore under Sandgate, dip at an angle of not less than 40° towards the north-west. This place, therefore, would appear to have been the site of some disturbance*.

At the west end of the cliff also, between Sandgate and Folkstone, the beds at the bottom of this lowest group dip inland, or towards the north, at an angle of about 40° or 45°, and the *strike* is from about 5° to 8° north of west, to the south of east, the vertical thickness being less than sixty feet.

Sir J. Tylden mentions, that in a quarry close to the brook at Underhill, the strata are so highly inclined as to be almost perpendicular; "curving," he says, "something like the flints in the chalk at the Isle of Wight, as if "they had been forced up." No traces of such disturbance met my observation on the coast; but this fact is deserving of notice, from the distinct proofs of elevation observable in a part of the series which corresponds to that here referred to, at Brasted, in West Kent, as will be mentioned hereafter. (38.)

(33.) The lower group seems, generally, to contain more calcareous matter than the upper divisions; and this in some specimens is splintery limestone, almost void of quartz, with but little of the green substance interspersed, in very minute grains. In such cases small portions might be taken even for mountain limestone. The concretions are commonly traversed by contemporaneous veins of calcareous spar, at right angles to the surface, and intersecting each other, one set being parallel to the *strike*, and the other nearly at right angles to it; they divide the mass, therefore, into pieces approaching

* It is not improbable that in this and other cases, where extensive subsidence has taken place, as at Eastware Bay and the back of the Isle of Wight, the occurrence was not confined to the period during which the sea has stood at its present level. If the level were ever higher than it is now, this would account for the ruins of the upper beds of the cliffs, which are frequently observable in the sea, beneath low-water mark.

to rhomboids; and sometimes, as in Septaria, they are thick in the middle of the beds, thinning off towards the top and bottom.

(34.) Some of the best sections of the group (*c.*) are to be found in the quarries about Seabrook*. In one of these the order was thus:—

	Feet.	In.
1. Very green-sand, alternating with courses formed principally of stem-like or vermicular branches of whiter sand, and including ferruginous patches. The petrifactions of this bed are very numerous. *Gryphæa sinuata* in great abundance.		
2. A group of stone beds; separated by yellowish calcareous sand and clay, called "Hassock" by the quarry-men. The upper portion especially abounds in petrifactions. The beds of stone are 18 inches to 2 feet in thickness: they are concretional, but nearly continuous.		
The total thickness visible is about	12	0

(35.) The lower beds are extensively worked in quarries, both for building and lime-burning, at Pluckley on the north-west, and at Great Chart on the south-west, of Ashford; and generally along the outcrop west of Aldington Corner, where the Weald-clay comes very near to the stony strata, a few feet only of sand rock being interposed. The line of junction is almost everywhere marked by the coming out of springs. The beds are nearly horizontal; and though the stone occurs in continuous masses, of sufficient size to answer well for building, these are evidently concretional. The interior of the blocks is frequently of a blueish colour, containing throughout minute dark grains: the exterior crust is brown.

(36.) The following is a list of the fossils which I have obtained or collected from the Lower Green-sand of this neighbourhood; in which, however, those of the three groups are not always distinguished: the statement of localities containing all that I find upon this point in my notes.

Fossils of the Lower Green-sand, *in the vicinity of Folkstone.*

Ammonites furcatus. Pl. XIV. f. 17. Lowest beds near Hythe. F.
A——— *Monile.* Between Sandgate and Folkstone. S. and Min. Conch.
A——— *Nutfieldiensis.* Hythe. Also Nutfield, Surrey. Min. Conch.
A———. Fragments of a very large new species occur in greenish "rag," at the bottom of the lowest beds of stone, in the quarries above Hythe. H.
Anomia lævigata. Pl. XIV. f. 6. In Kentish rag, near Sandgate. S. and So. Lympne. H.

* Those near Court-at-Street, which have furnished so many fossils to the collection of Mr. Hills, I have not examined.

Anomia radiata. Pl. XIV. f. 5. Near Sandgate. S.

Astacus. (Claws of a small species.) Near the contact of the gault and green-sand. F.

Astarte obovata. Near Hythe. H.

A——. Fragments, apparently of three different new species, but too indistinct to be determined, were found at Lympne. H.; and Sellinge. S.

Astrea. Folkstone. Geol. Soc.

Avicula pectinata. Pl. XIV. f. 3. In siliceous rag, near Risborough. F.

A——. A smooth species, probably new. Upper sand beds, between Sandgate and Folkstone: in concretional siliceous stone, passing into chert. F.

Belemnites. (Species doubtful.) Indistinct specimens in the quarries at Hythe. F.

Cardium? dissimile. A cast. Quarry near Ivy Cottage, Sandgate. Lowest beds of lower green-sands. F.

Corystes. (Species doubtful.) Lower green-sand, near Hythe. H. and S.

Cucullæa costellata? Near Seabrook. F.

C——— *decussata.* Quarry near Ivy Cottage, Sandgate. S. Also near Court-at-Street. H.

C——— *glabra.* Quarry near Ivy Cottage. F.

C———. New species; indistinct. Ivy Cottage. F. Near Seabrook. S.

Cidaris scutiger, (Goldfuss.) Court-at-Street. H.

Cyathophyllum, (Goldfuss.) Folkstone. Geol. Soc.

Cyprina angulata. (Syn. *Venus.* Min. Conch.) In soft greenish calcareous sand rock of the middle group; shore between Folkstone and Sandgate. F. Quarries above Hythe, and near Lympne. H.

Echinus. (Species uncertain.) Court-at-Street. H.

E——— arenosus. Pl. XIII. f. 1. Quarry near Hythe.

Exogyra lævigata. Court-at-Street. H.; and vicinity of Sandgate, near Seabrook; F. (Perhaps the full-grown state of *Chama conica?*) Mr. Sowerby.

Gastrochæna ———? Near Sandgate. S. Quarries above Hythe. H. In the shell of an Ostrea; in compact stone, full of dark green particles.

Galerites subuculus, (Goldfuss.) Near Hythe. S.

Gervillia aviculoides. (*Perna.* M. C.) Court-at-Street. H. Also in the lowest group of stone, near Sandgate and Seabrook, and in the quarries above Hythe. F.

G———. A new species? Court-at-Street. H.

Gryphæa sinuata. Near Court-at-Street. H.; and Sandgate. F.; also near Ashford. Min. Conch.

Hamites gigas.* Quarry, west of the Pesthouse, Sandgate. S. Also Lympne. H.

H—— *grandis?* From Lympne. H.

H—— Hillsii. Pl. XV. figs. 1. and 2. Quarries near Hythe. H. Court-at-Street, near Lympne. This species is named from Mr. Hills, whose collection has thrown great light on the fossils in his neighbourhood.

H—— *nodosus.* Near Hythe. H.

* The character and relations of the Hamites are still so obscure, that the species are here given with considerable doubt.

Isocardia similis. From Sandgate. F.

Lima semisulcata. Pl. XI. f. 10. (*Plagiostoma semisulcatum* of Nillson; *Petrif. Suecana.* Tab. IX. f. 3. p. 25.) In the Kentish rag, near Court-at-Street; small specimens. H. Vicinity of Hythe. Miss A. Smith.

Lingula ovalis. Lowest green-sand, near Sandgate. S.

L—— ? truncata. Pl. XIV. f. 15. Near Hythe. S.

Lucina ? Near Court-at-Street. H.

Lutraria? Lympne. H.

Madrepora, Goldfuss, (*Pocillopora*, Lamarck). Folkstone. Geol. Soc.

Modiola alæformis. Near Court-at-Street. H.

M—— *aspera* ? From Hythe. F.

M—— lineata. Pl. XIV. f. 2. Vicinity of Hythe. H. and F.

M—— *parallela.* Near Maidstone. Min. Conch.

M—— ? Casts. Near Lympne. H.

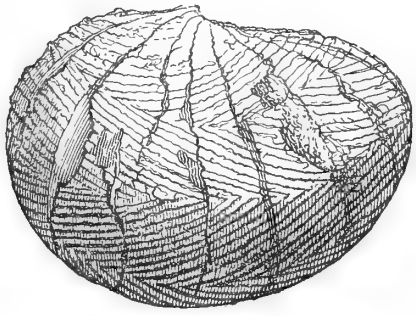
Mya plicata. (See *Panopæa.*)

Nautilus elegans. Near Hythe. H. and F.

N—— *inæqualis.* Folkstone. Min. Conch.

N—— *simplex.* Very much compressed. Probably from the lower part of the middle green beds, near Sandgate. F.

N—— plicatus. Near Lympne. H. Some specimens 8 inches high, and 8 in diameter. The zigzag markings on the outside are very characteristic.



N—— *undulatus.* Lympne. H.

Nucleolites carinatus. (Goldfuss, Tab. XLIII. f. 11.) Court-at-Street, H.

Nucula ovata. Near Lympne. H. and F.

Ostrea carinata ? Near Court-at-Street. H.

O—— *macroptera.* Folkstone. F.

O—— (Species doubtful.) A very thick shell. From the upper sand beds, near Sandgate. S.

O—— (Species doubtful.) Shell thin. In the upper beds. S.

Panopæa plicata. In the green middle beds, near Ivy Cottage, Sandgate. F. In a mass of deep-green colour, near Court-at-Street. H.

Panopæa? rotundata. Pl. XIII. f. 2. Near Court-at-Street. H.

Pecten obliquus. Near Court-at-Street. H. In firm greenish rag: quarries above Hythe. H. and F.

Pecten orbicularis. Lowest group of stone beds; near Hythe. F.

P—— quinquecostatus. Upper sand, between Sandgate and Folkstone. S. Also in the lowest group, near Court-at-Street. H.

Pectunculus umbonatus. Middle green beds, Ivy Cottage, Sandgate. F.

Pentacrinus. Stems and branches. Between Sandgate and Folkstone, in calcareous sandstone. S. Also found in a quarry near Lympne. H.

Perna tetragona. Near Lympne. H.

Pholadomya. A fragment. Near Court-at-Street. H. Perhaps the same with specimens found near Pulborough by Mr. Martin.

Pholas?? giganteus. Pl. XIV. f. 1. Near Court-at-Street, Lympne. H. and G.

P—— priscus. Sandgate. Middle green beds, behind Lord Darnley's house. S.

Pinna? crassa. New species. The specimens are large, but indistinct. Court-at-Street. H. and S.

Plagiostoma elongatum. Lowest beds, near Court-at-Street. H.: and Folkstone. M. C.

Plicatula pectinoides. Near Court-at-Street. H.

Pollicipes radiatus. Pl. XI. f. 6. Near Lympne. H.

Rostellaria. (Species doubtful.) Near Court-at-Street. H.

Serpula antiquata. Near Folkstone. M. C.

S—— variabilis. Pl. XXI. f. 7. Near Court-at-Street, in hard green Kentish rag. H.

Siphonia. (Parkinson.) Stems. Upper beds of the lower green-sand; in spongy siliceous concretions. Valley north of Sandgate. S.

Spatangus retusus. (Goldfuss, Tab. XLVI. f. 2.). Near Sandgate. S. F.

S———. Three other species, apparently new, but indistinct. Near Court-at-Street. H.

Sphæra corrugata? Casts in the lowest part of the middle sand. Quarry near Ivy Cottage, Sandgate. S. Also near Court-at-Street. H.

Terebratula biplicata. Lowest group of the sands, near Court-at-Street. H.

T——— convexa. Pl. XIV. f. 12. Near Hythe. H.

T——— elegans. Pl. XIV. f. 11. Near Lympne. H.

T——— elongata. Near Court-at-Street. H.

T——— Faba. Pl. XIV. f. 10. Between Folkstone and Sandgate. S.

T——— Gibbsiana. Near Sandgate and Folkstone. S.

T——— latissima? Near Hythe, and Court-at-Street. H.

T——— oblonga. Near Hythe. F.

T——— ovalis. Middle stratum, between Sandgate and Folkstone; and near Ivy Cottage, Sandgate, S. and F.: also in the lowest group, Court-at-Street. H.

T——— ovata. Quarry above Hythe: young and small. S.

T——— prælonga. Pl. XIV. f. 14. Near Ivy Cottage, Sandgate; and shore between Sandgate and Folkstone. S.

T——— quadrata. Pl. XIV. f. 9. Near Hythe. H. and S.

T——— Sella. Near Court-at-Street. H.: and quarries near Hythe; very numerous, in clusters. F. Also at Chart, Kent. Min. Conch.

T——— Tamarindus. Pl. XIV. f. 8. Near Hythe. S.

Terebratula. Two or three other species, probably new. Near Hythe. S.

Thetis major. Lowest beds of the middle group, near Ivy Cottage, Sandgate. S. and F.

Trigonia alæformis. Near Court-at-Street. H. Ivy Cottage, Sandgate. Middle beds of the lower green-sand. F. Also near Seabrook. G.

T——— clavellata. Seabrook. S. Also about Court-at-Street. H.

T——— elongata. (var. of *T. costata.* Min. Conch.) An imperfect specimen. Near Court-at-Street. H.; and Ashford, Kent. Mantell.

T——— nodosa. Near Seabrook. S.

T——— spinosa. (Minch. Conch.) Near Seabrook. S. Also near Pulborough. Mr. Martin.

T——— spinosa var. Pl. XIII. f. 3. Shorn Cliff, near Sandgate. G. and F.

T———. New, but indistinct. A cast. Hythe. H. The same with a fossil of Shanklin, Isle of Wight. So.

Trochus. Species doubtful. Pl. XIV. f. 16. Near Court-at-Street. H. Also Boughton-Mount quarries, near Maidstone. F.

Venus angulata. (See *Cyprina.*)

V—— caperata? (See *Cytherœa.*)

V—— ovalis? Lowest beds of the middle group: quarry near the Ivy Cottage, Sandgate. S.

V——. Cast of a small species. Lowest group of stone: quarries above Hythe. H.

Vermetus polygonalis. Near Court-at-Street. H. Near Sandgate, and Seabrook. Min. Conch. Also from Bonchurch, and Ventnor Cove, Isle of Wight: but in the *upper* green-sand, or in gault. F.

Wood. Coniferous, silicified. Near Folkstone, and Wilsborough. Rolled fragments are frequent, at the junction of the gault with the top of the sands.

Interior of Kent.

(37.) I have dwelt the longer on the description of the coast near Folkstone, on account of the distinctness with which the strata are disclosed there, and of the geological celebrity of the place; which has the advantage, also, of being easily accessible to foreigners, from its proximity to France. The details above given will supersede the necessity of minute description in many of the following sections.

The strata succeeding the chalk offer but little variety between the coast and the vicinity of Godstone, in Surrey. The Upper green-sand is throughout comparatively obscure. The gault, which in general occupies but a small and narrow valley at the foot of the chalk escarpment, is extensively unveiled at the entrance of the river gorges, and in those cases its surface is varied by hills and other inequalities. The Lower green-sand agrees generally, both as to structure and composition, with that of Folkstone, but the proportion of calcareous matter decreases from Maidstone towards the west.

(38.) Extensive quarries have long been worked in the lowest part of the green-sand at Boughton, on the south of Maidstone, the geological relations of which are the same as at Hythe. The stone for the construction of Westminster Abbey is said to have been procured there. It is a variety of Kentish rag, like the Hythe stone, in nearly continuous beds, alternating with a soft sandrock, called by the workmen "hassock," and passing occasionally into chert*.

At the top of these quarries irregular fissures or cavities, approaching to a conical figure, called "vents" by the workmen, are frequent. These are filled with loose rubbly stone and sandy clay. In one of them the bones of hyænas were found, in 1827, by the late Mr. Braddick, of Boughton Mount, under circumstances like those in which similar remains occur in fissures in other parts of England. My specimens include several fragments of the long bones and jaws, with the canine and incisor teeth, some of which are much worn down by use; and these are accompanied by *Album Græcum*†.

Fragments of chalk-flints are found upon the surface near Boughton, about four miles and a half from the outcrop of the chalk: a fact which deserves attention, as such remains of the superior strata have been supposed either not to occur, or to be extremely rare, within the space between the North and South Downs.

(39.) The manner in which the rivers make their way to the sea, by an apparently unnatural course, across the ridges both of the chalk and the inferior strata, is one of the most interesting points in the general structure of Kent; and has been already dwelt upon by Mr. Conybeare‡, Mr. Scrope§, and Mr. Martin‖.

(40.) The great variation in width of the space occupied by the strata between

* This better stone is called here "Calkstone" (Kalkstein?). Foreign workmen were often employed formerly in the British mines and stone works; and in some other instances,—as at the mines of Lead Hills in Scotland, they have left traces of their native languages in the technical terms.

† Since these pages have been at the press, the remains of an animal, which Mr. Mantell himself has ascertained to be distinctly an Iguanodon, hitherto found only in the freshwater beds of the Wealden, have been discovered by Mr. Brinstead, at Rockhall, near Maidstone, in a stratum of Kentish rag, abounding in the usual fossils of the Lower green-sand. They confirm the propriety of referring to the same animal the great bones and the teeth, previously discovered at Tilgate and other places in Sussex. See Jameson's Edinb. Journal, July 1834. (Vol. XVII. p. 200.) A full account of these and other new remains of this extraordinary reptile, will be laid before the Royal Society by Mr. Mantell.

‡ "Outlines," &c., pp. xxvii. and 145.

§ "On Volcanos," p. 213.

‖ "Memoir on Western Sussex," pp. 12—57.

the chalk and the Weald clay is another very prominent feature of this part of the country; and though it arises, in part, from the extensive denudation at the entrance of the gorges where the principal rivers traverse the chalk ridge, yet even if these were filled up, and the range of the downs between the coast and Dorking rendered uniform, the space occupied by the lower strata would be found to vary considerably*. The chief cause of this irregularity is the difference of the angles at which the strata rise in different places; the heights also which the sands attain, having a proportionate variation.

(41.) In the upper part of the Lower green-sand between Sevenoaks and Godstone, a ridge or saddle can be traced for several miles, in a direction nearly parallel to that of the central range of the Hastings sands, its course being from about 10° south of west to 10° north of east. The places where I have seen the structure of this ridge most distinctly, are on a line passing from Montreal Park, through Sundridge, to the grounds of Brasted Place, in the course of which several sections have been exposed. The strata consist of yellowish and somewhat ferruginous sand, and "hassock," including beds of a bluish stone, like that of the Boughton quarries and the vicinity of Folkstone: the fossils, also, are the same.

The ridge just mentioned is probably continued eastward; but my observations in that direction did not extend beyond a place called Cold Harbour, immediately on the west of Montreal Park, where the beds rise towards the south, at an angle of about 20°; the bend, also, or summit of the ridge being there exposed, on the verge of a small wood, but less distinctly than at Brasted Place, hereafter mentioned. Its continuity, however, is in several places interrupted by breaks or openings, from 50 to 100 paces in width, where a uniform surface at a much lower level is continued from north to south, across the direction; as if the ridge had been cut away in those places, or wide transverse fissures had been partially filled up and levelled over†. The first of these breaks is about sixty paces from west to east, and the summits of the heights

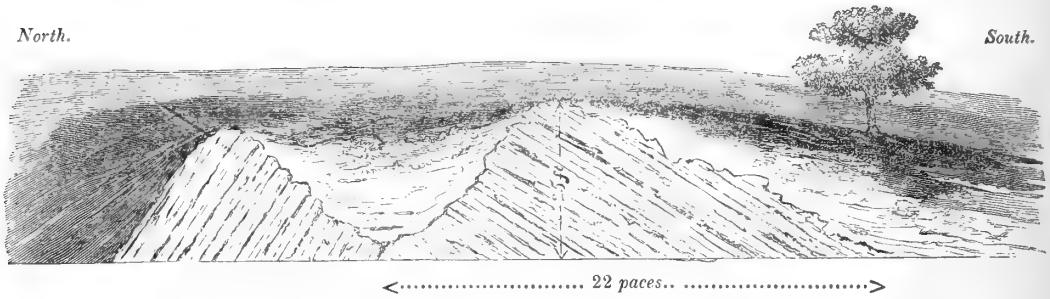
* On the coast line the distance from the chalk at Folkstone Hill to the outcrop of the lower green-sand at Aldington Corner, is about ten miles; but from Lenham to the outcrop is not more than two. A line parallel to the last, from Boxley, passing through Maidstone, is rather more than six miles long; but from Wrotham to the outcrop is less than four; at Tandridge, on the east of Godstone, less than one and a half; and at Reigate little more than one mile. On the west of Reigate the lower green-sand again runs out four miles, to Leith Hill, which is 993 feet above the sea. These details could not be expressed on the small map annexed to this paper: for better illustration the reader is referred to Mr. Greenough's Geological Map of England, and to the Ordnance Survey.

† A remarkable break of this description occurs between two portions of wood immediately on the north of the letter "*y*," of the word "*Dry-hill*" in the Ordnance map.

which it separates are about seventy feet above their base. The strata, which form the southern slope of the ridge, dip southwards at an angle of about 45°, and the apparent distance (or chord of the curve) from the beginning of the rise on either side is rather more than a furlong. The wood near Cold Harbour is full of old quarries, which seem to have been dug into the top of the saddle.

(42.) A very good view of these elevated strata is disclosed on the east of a lane which strikes off from the main road between Bessell's Green and Sundridge, passing Dry Hill Farm; quarries having been opened there in two detached points, marked A and B in the subjoined sketch. It is difficult to estimate the width of the ridge at this place from north to south, its terminations not being distinct, at either extremity, but it seems to be about 1200 paces.

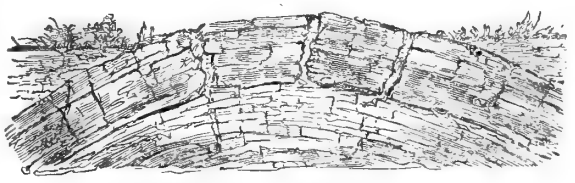
At the more northern of these quarries, A, the beds are distinctly, but slightly, curved; and the strike is not parallel to the general course of the ridge, but runs from about 16° east of north to 16° west of south; forming, with the direction of the ridge, an angle of about 64°. At the second quarry, B*, (of which a sketch on a larger scale is given below,) both sides of the saddle are visible within the distance of a few paces, the beds on the north rising at an angle of about 60°, while on the south they decline at an angle of about 45°.



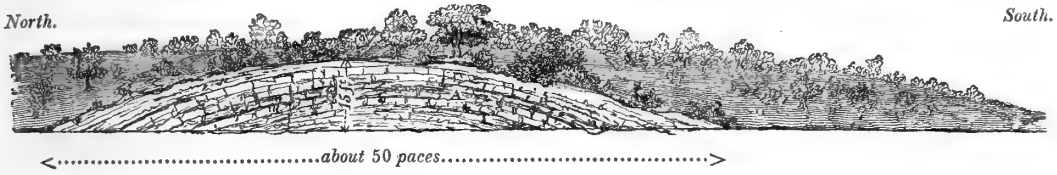
In the southern portion of this section, which is about twenty-two paces in length, and twenty-five feet high, I counted twenty-two beds of concretional stone alternating with sand, and varying in thickness from eighteen inches to nine.

* This place is immediately on the east of a barn on the road-side, north of Dry Hill Farm, and about 270 paces distant from A, on a line bearing about 36° west of south.

A second break or open space, like those above mentioned, (p. 133.), occurs immediately on the west of Sundridge Church, which stands on the northern slope, very near the summit of the ridge; and a third break, with a flat of about 100 paces, separates the continuation of that height from another, occupied by a small wood belonging to Brasted Place, and called by the inhabitants the "New World": and here the top of the curve is visible in several places, from one of which this sketch was taken. The cracks in the principal bed here represented, (which is about nine-inches thick,) are wide and irregular; but the stone has every appearance of having been once continuous.



The bending of the strata is also very well disclosed in the grounds of Brasted Place itself, at the opposite side of the lane by which they are separated from the little wood of the "New World." The curve is there less rapid than in the wood; and the thickest bed of stone, marked A, is traversed by cracks from a quarter to half an inch in width, the separated portions being somewhat displaced, as if they had been forced out of continuity.



(43.) A continuation of the ridge above described may be traced westward from Brasted Place, for about four miles; and on the roadside ascending to the Chart near Moorhouse, about midway between Westerham and Lympsfield, beds are exposed, which dip rapidly to the north; obviously forming a portion of a saddle, like that of Dry Hill, and, to all appearance, a prolongation of it.*

From what I have seen in other parts of this country, I have little doubt that many of the ridges within the tract occupied by the lower green-sand may be ascribed to similar disturbances of the strata. A slight indication of something of this kind near Folkstone has been already referred to (32.). On the Ordnance map a prominent range is represented as running nearly north-west and south-east, from the village of Seal, through Seal Chart, to the

* Marks of disturbance along a line of direction different from that described in the text, are observable also about half a mile south of Dry Hill, near the Manor Farm House; where the beds on one side of the ravine dip towards a point about 20° south of east, while on the opposite side they are inclined to the west of north.

heights above Stone Street on the south of Ightham Common. This, if not very much exaggerated, is probably a derangement like those just mentioned. The greater ridge of the Hog's-back itself, on the west of Guildford in Surrey, of which the direction is nearly continuous with that of the ridge at Brasted, may be also connected with it; since the line of the Hog's-back, if prolonged eastward, would pass through the high range of sand hills between Shalford and Martha's Chapel, and thence almost directly through Park Hill, Cockham Hill, and Tilburstow Hill, which last-mentioned place is the seat of a similar disturbance. The distance from Tilburstow to the inclined strata at Moorhouse, is not much more than four miles, and the whole course of this elevated line is almost uniformly from east to west; the line from Moorhouse to Montreal, through Sundridge, deviating from that direction only a few degrees to the north. Mr. Martin has described similar cases of much greater prominence and interest in Western Sussex*.

(44.) The abrupt rise of the beds in many of these ridges, and the speedy return of the ground to its general inclination, imply the action of a force which, if direct, must have been very near the surface, and too much circumscribed to be reconcilable either with the effect of gaseous expansion or the impulse of mineral matter in a state of fluidity. The space between the north and south chalk downs seems, in fact, to have been elevated, not by the mere protrusion of one central ridge, but to have been broken up in several different places, so that large portions were thrust outwards, or bent into ridges, by a lateral push, as when a cloth is wrinkled on a table; a mode of accounting for the formation of such inequalities of the surface, which seems more probable than the action of any direct violence from beneath†.

* "Memoir, &c.," p. 76 et seq.

† There is indeed another hypothesis, which would account for the formation of prominences of small extent, by forces originating at very great depths. If we suppose a series of strata, comparatively soft and flexible, to be deposited over a tract composed of older rocks, with hills and ridges on its surface, and the whole to be then thrust outwards by a force beneath, the protuberances of the lower mass would compress and bend the strata above them into forms corresponding with their own;—just as in bound books the little inequalities of the cover, or any of the leaves, are impressed on the adjacent pages, and sometimes propagated through a large part of the volume. Nor is this case wholly imaginary. The masses of granite which are found, in many instances, to project above the disturbed strata adjacent to them, must have been elevated after they had cooled,—when their comparative solidity must have been very great:—and among the newer formations, the interval of time between the deposition of many of the groups, now in immediate contact, (as of the red marl and the oolites, near Bath,—the mountain limestone and greensands in the Lower Boulonnois,) must have been more than sufficient both for the condensation of the lower strata, and their subsequent erosion into prominences and valleys, even if the original surface had been uniform.

SURREY.

(45.) *Godstone.*—The upper green-sand assumes a new character near Godstone; and a step-like projection at the foot of the chalk appears there more distinctly than in the country to the east. As the productions of the little district between Godstone and Reigate are valuable in commerce, and its structure has been a subject of some doubt, I have given a separate map of it, in Plate VII. fig. 2.* The section, Plate X. a., No. 2., on the line from the chalk through Godstone, shows the position of the firestone beds in the upper green-sand; with the site of a remarkable elevation of the strata at Tilburstow Hill, an account of which has been already published by Mr. Mantell†: and No. 3., the section through Merstham, includes the site of the Fuller's-earth pits of Nutfield.

(46.) The firestone subordinate to the upper green-sand, in this part of the country, was, in 1827, extracted only between Godstone and the west of Reigate. The principal pits were situated on the west of the London road to the former place. The stone was obtained by an adit between five and six feet in height, and the succession of the beds affording it was thus:

Section of one of the Firestone Pits near Godstone.

	Feet.	In.
1. "*Hard roof.*" This, like the firestone beneath, is a uniform fine-grained conglomerate or sandstone, effervescing strongly with acids, and easily cut into any desired form. Throughout the stone are dispersed numerous minute scales of mica, and dark particles, scarcely perceptible without a lens. It forms a roof to the mines, of such firmness as to support itself to a width of 17 feet, extending indefinitely inwards.	1	3
2. "*Green bed*" of the workmen. (*Firestone.*) Stone of the same nature as the last, but harder and somewhat finer in grain, easily broken down into sand, effervescing. The beds 2. 3. and 4. though separated by seams of stratification, are of nearly uniform character.	1	9
3.	1	4
4.	0	10
5. A bed of bluish grey siliceous concretions, called "flints" by the workmen, passing into stone like that above mentioned. Fracture flat-conchoidal. Yielding with great difficulty to the knife; but effervescing slightly. The greyer stone near these concretions is much harder than elsewhere. The siliceous matter as it becomes more pure acquires greater hardness, with a splintery fracture and a glimmering lustre; and the micaceous particles, which are numerous in the softer varieties, are then scarcely apparent.	0 to 0	3 to 4
6. "*Green bed*;"—like 2. 3. and 4.‡	0	10

* In the small maps of this Plate the inequalities of the surface are not expressed: but the colours can easily be transferred to the Ordnance map. † "Fossils of Tilgate," &c., p. 22.

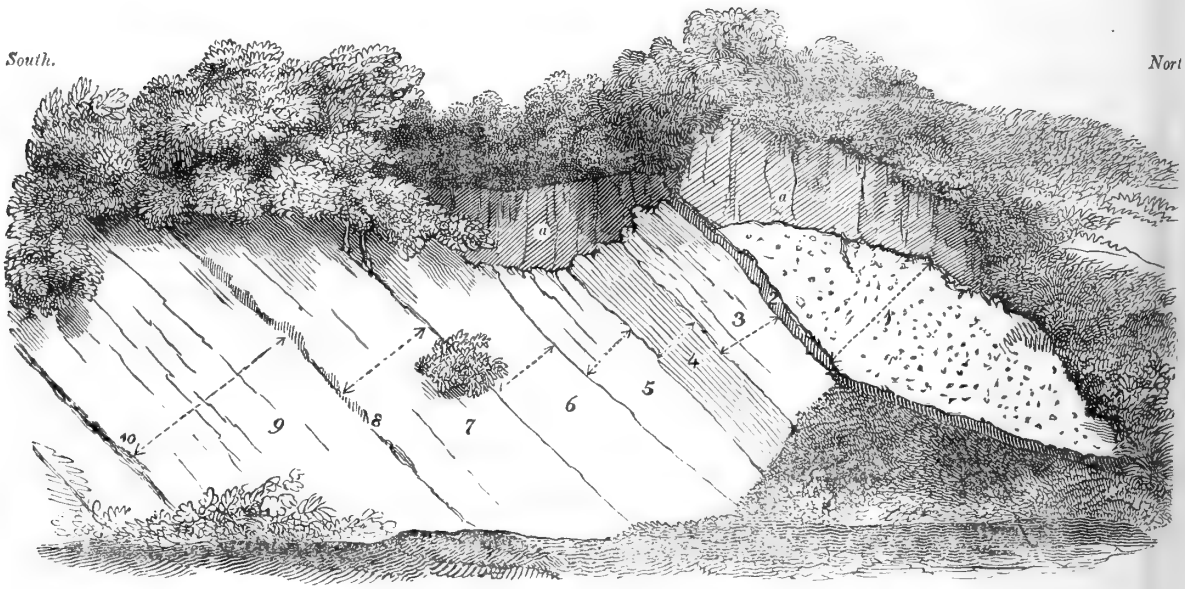
‡ The more uniform and softer rock of these pits is used, principally, for lining fire-places

7. Bottom of the quarry. Stone unfit for working, from its containing much flinty matter.

All these strata dip at a very small angle to about 20° west of south. The rock is traversed by fissures, which divide it into somewhat rhomboidal masses; and smaller cracks are sometimes found within the blocks of stone.

(47.) The gault hereabouts occupies a tract which bears the name of "Blackland," and forms a slight depression below the band which affords the firestone.

(48.) The lower green-sand has distinct indications of a subdivision into three, like that of the vicinity of Folkstone (16.). On the line of section, No. 2. Plates VII. and X. ponds are frequent, in a situation corresponding to that of the greener middle group (24.); the surface being comparatively low, with vegetation of a somewhat different character. The stony beds of the lowest group then rise to form the escarpment of Tilburstow Hill*, which is nearly on a level with the chalk downs; and at the highest point, there is decisive evidence either of a sinking towards the chalk, or of elevation in an opposite direction; for at the top of the hill, the beds, which on the north of that place rise uniformly at an angle of not more than 10°, are suddenly thrown up to about 45°. The appearance of the section here is represented in the sketch subjoined:



and furnaces, but is employed also for buildings under water. Great care is necessary, in building, to place the blocks so that the planes of stratification shall be horizontal. The equivalent of these beds in the upper green-sand of the continent, (the *Pläner kalkstein* of the Germans,) is employed for exactly the same purposes, at Aix-la-Chapelle and other places.

* This is the spelling of the Ordnance map: the word in the country is pronounced "*Tilbuster.*"

Inclined Strata, near the bottom of the Lower Green-sand, Tilburstow Hill.

	Feet. In.
Soil and loam (marked *a a* in the cut).	
1. Soft nearly uniform sand; when dry of a bright buff colour ..... This has the appearance of having slid or subsided upon the next bed below. Immediately above 2. the sand is green.	about 6 0
2. Fuller's-earth; very like that in the upper part of the pits at Nutfield, hereafter mentioned, and also like that which occurs in the lower green-sand at Brill in Buckinghamshire. This clay becomes soft and is diffused in water, but does not break down with the rapidity of common Fuller's-earth. The bed varies in thickness from 6 inches to 12: the masses of which it is composed have smooth surfaces and a saponaceous feel, with the aspect and lustre of bee's wax, probably produced by compression and motion on each other	0 6 to 1 0
3. A bed consisting of chert and soft sandrock ("Hassock"), intimately mixed, and passing into each other; about ..... This and the beds 4. 5. and 6. end abruptly above, as represented in the sketch.	3 6
4. A course composed of almost continuous bands of brownish grey chert, from 3 to 6 inches thick, alternating with, and passing into, soft sandrock. This chert is like that on the northern surface of the hill, where it is much used for repairing the roads. By exposure it becomes divisible into slaty portions, approaching to a rhomboidal figure	6 6
5. Soft sandrock ("Hassock"), including green particles: the hue is various where exposed. In some places tinged with oxide of iron	about 3 6
6. Sand; green while it is moist, but when dry and exposed nearly white, containing layers which consist of stem-like or vermicular portions of white, translucent, quartzose sand, surrounded by sand of a green colour. This contrast of colour becomes indistinct in dry specimens, but is very conspicuous when they are moistened. The white vermicular portions have a border of darker green than the rest: they are generally about $\frac{1}{8}$th of an inch in diameter, somewhat curved, and in some cases have short lateral branches with round extremities. This remarkable structure is very characteristic of several parts of the lower green-sand, and is probably connected with the former presence of organized bodies	varying from 4 0 to 6 0
7. Coarse yellowish sandrock	
8. Here ferruginous matter is more abundant, and the sand is concreted irregularly into nodular masses nearly continuous. 7 and 8 together are about 15 feet thick.	15 0
9. Ferruginous bands, like 8: a conglomerate of quartz grains, cemented by oxide of iron, with adhering sand, which in some places is white, and looks like mortar, but does not effervesce	
10. Sand, with dark particles, and irregular tortuous seams of a ferruginous compound, like the carstone of Norfolk, consisting of fine rounded grains of quartz, cemented by hard, dark reddish brown, oxide of iron. This passes at the bottom into a less ferruginous sand, which is apparently continued down to the Weald clay. 9 and 10 together are about 15 feet thick.	15 0
Total thickness....about	60 feet.

(49.) *Merstham.*—The aspect of the amphitheatre formed by the outcrop of the chalk and upper green-sand around this village is very characteristic: a prominent ridge of the latter stratum, passing from Blackditches to the south of Gatton, in a nearly circular curve, above which the chalk downs rise, with a similar curvature (see Plates VII. fig. 2., and X. a. No. 3.). Merstham occupies nearly the middle of the line which has been worked upon for firestone; the extreme points to which the quarries have extended of late years being near Godstone on the east, and Buckland Green on the west. The village stands on the confines of the upper green-sand and the gault*, a little to the south of an opening or gorge in the chalk, through which runs one of the principal roads from London to Brighton. The beds dip at a very small angle, towards the north; and those which include the firestone are visible to a thickness of about thirty feet, projecting like a step beyond the foot of the chalk escarpment. The works had been discontinued for some time before I visited the place; but the following list of the strata was given to me by the person who had superintended them†.

List of Beds at Merstham, Surrey.

	Feet.	In.	Feet.	In.
[*Lower beds of the Chalk.*]				
1. "*Chalk.*"				
2. "*Limestone.*" Grey marly chalk; about			150	0
3. "*Burry chalk*:" the "Craie Tufau" of the French. This will not burn to lime, but goes to dust in the kilns.....			50 to 60	0 0
[*Upper Green-sand.*]				
4. "*Quarry stone*;" (Firestone) subdivided thus:				
a. "*Roof*," (sand 2 feet, soft stone 2 feet)? Total, about ..... This stratum is of great firmness and stability: the roof supporting itself perfectly in the drifts worked into the hill, which are 30 feet wide.	4	0	about 25	0
b. "*Firestone*;" including "*flints*" (chert), about 2 feet from the top: about	5	6		
c. "*Good hard building-stone.*"	2	0		
d. "*Burry stone*;" about	16	0		
[*Gault.*]				
5. "*Marl.*" Gault: the apparent thickness of which, in this part of the country, agrees with that on the coast.		about	150	0

All the beds become thinner towards the outcrop.

* A well at the Feathers-Inn is 150 feet in depth, with a boring of 60 feet at the bottom (in the whole 210 feet), all in "clay" and "marl." The boring, $2\frac{1}{4}$ inches in diameter, after going down to 60 feet, brought up such a quantity of water, that the well-sinker was drawn up in great haste, and the water rose to within 40 or 50 feet of the surface. Much sand, which had come up through the bore, was afterwards found in the bottom of the well.

† A more full account of the Firestone pits here, has been published by Mr. Webster, Geol. Trans., First Series, vol. v. p. 355.

(50.) The rise of the Lower green-sand is here very well defined; and the soil over the upper ferruginous beds of the formation is called "hazel-mould," in distinction from the "black-land" upon the gault. Immediately on the south of the ridge formed by this first member of the sands, a slight valley or depression, with a moist and more fertile surface, is occupied by cohesive sand of a dark greenish hue and softer texture, which corresponds to the middle group of Folkstone, above described, (16.) and (24.). The retentive quality of this latter stratum, which gives a somewhat marshy character to the tract in which it occurs, and the approach of its hue and texture to those of clay, have deceived even experienced geologists, and given rise to some mistakes respecting the lower strata of this neighbourhood. The section No. 3, I believe, expresses their true order and relations.

(51.) Fuller's-earth has been dug in this part of Surrey, beyond the memory of the oldest inhabitant. At present the extraction is confined to the neighbourhood of Nutfield. The beds come up near the top of the lowest member of the green-sand, and occupy a line on the north side of a ridge, which extends from the east of Nutfield nearly to Redstone Hill, on the west of Copyhold Farm. About two miles west of Nutfield, nearly upon the ridge, was a pit, by which the earth was extracted from a stratum six to seven feet thick; and at Colmonger's Farm another, of which the section was thus:

Fuller's-Earth Pit, near Nutfield.

	Feet.	In.
1. Greenish sand, occupying irregular cavities on the top of the clay, 2.	about	
2. Very tough clay (impure Fuller's-earth) with the aspect of steatite. [See No. 2. of the Section at Tilburstow Hill, p. 139.]	3	0
3. Sandrock, abounding in green particles; about	4	0
4. A range of sandy nodules, of firmer consistence than 3.	1	0
5. Thin courses of bad Fuller's-earth	0 to 0	4 8
6. Continuous sandstone, forming the roof of the "earth-pits," and sustaining itself without support to a width of 11 yards	2	10
7. Ochreous clay	0	2
8. *Fuller's-earth*, of an uniform bluish colour* ..... In this stratum, about 3 or 4 feet from the top, detached nodules are found, (from six inches to nine in diameter,) of sulphate of barytes, crystallized in oblique four-sided prisms, truncated at the edges and bevelled at the extremities, semi-transparent, and of a wine-yellow colour	16	0
9. White sand.		

The thickness of sand beneath,—between this stratum and the Weald clay, I did not ascertain.

The dip of the strata above detailed is about one in fifteen: (the angle, therefore, between 3° and 4°,) towards a point about 40° west of north.

* This was sold at the pits (September 1828) at 5*s.* per ton. The yellowish earth of another

(52.) *Reigate.*—The map and sections, Plate VII. fig. 2. and X a., Nos. 2. and 3., sufficiently indicate the general relations of the beds here, which have been already the subject of a paper in the Geological Transactions by Mr. Webster*; where a sketch is given of the history of the remarkable ancient quarries at this place. The firestone forms a terrace beyond the chalk, nearly level with the top of the remotest sand-ridge; and the gault runs out from the base of the terrace, at first horizontally, and then rises towards the tunnel, by which the road is conducted through the first ridge of the Lower green-sand†, here composed of cream-coloured and yellowish sandrock. From the town of Reigate the strata rise again towards Cockham Hill: so that there are here two ridges; first, that through which the tunnel is cut, and secondly, the southern ridge, formed of the lowest sand beds,—with what appears to be the middle, greener sand between. At Earlswood Common, about a mile to the east of the outcrop, the clay of the Wealds is found. The sudden fall from the chalk to the valley of Reigate and the abrupt rise thence to the outermost ridge of Red Hill, &c., is exceedingly striking. At Reigate Heath, on the west of the town, the vale which seems to be occupied by the middle sands is rushy and moist, bearing pools upon its surface: but the fall of the ground still farther west, where the continuation of the outer ridge of sands might be expected, is also a remarkable feature.

(53.) In proceeding westward, the rise of the sands at Buckland is likewise very rapid. Thence to Holmwood Common, on the south-west, no observations have been made, but the boundary between the green-sands and the Weald is less obviously marked; and there is a strong contrast between this space and the prominent ridges of Leith Hill; the lower tract, it will be observed, being that in which the streams converge to join the Mole before its passage through the gorge at Dorking.

(54.) It will be seen, even from the map (Plate IX.), that the outcrop of the Lower green-sand, from Reigate to the head of the valley of the Wealds, is not continuous; two, if not three, distinct tracts of this formation, bounded

pit was more in request; the price, however, the same. It is necessary for the purposes of the woollen manufacturer, that the Fuller's-earth should be free from any admixture of ochre or sand, which are found to cut the cloth.

* First Series, vol. v. p. 353, &c.

† The relations of a stratum of dark greenish sandy clay, about seven feet thick, immediately above the tunnel at Reigate, are at first sight doubtful. It might be taken for an advanced portion of the gault; but is, more probably, a subordinate bed within the first division of the Lower green-sand;—a detached portion, as it were, of the middle greener beds, which it resembles in mineral character. A similar bed occurs, in a corresponding situation at Pulborough, which Mr. Martin, with whom I examined it, has since ascertained to belong to the place here mentioned.

on the south by almost rectilinear escarpments, projecting successively beyond the narrow and comparatively regular line of the previous outcrop, on the east*. The breaks between these steps coincide with the gorges of the Mole and the Wey; a fact in favour of the hypothesis which ascribes the formation of these gorges to transverse fissures. 1.—The first of these tracts of sand lies between Leith Hill and the opening cut across the sands towards Guildford, by the south-eastern branch of the Wey†, in which the Surrey and Sussex canal has been dug. Its southern verge extends from Leith Hill, through Holdenbury Hill, to Bearland and Stroud-Green, with a mean breadth from the chalk of about 3½ miles. 2.—The next step projects about 3 miles further south, with an average breadth of about 6 miles; and its escarpment is nearly parallel to the Hog's-back throughout the greater part of its length, from the Telegraph Hill, south of Hascombe, to Emily Farm, a little east of the centre of a line from Hindhead to Thursley. The anticlinal line, hereafter mentioned, along the top of Grayshot Down, may perhaps be the continuation of a ridge, or saddle, of which the beds rising towards Hascombe are the remaining northern portion, the southern slope having been carried away by denudation‡. 3.—The sands on the north of the valley between Ludgershall and Harting-combe, may possibly be considered as a third step in these parallel outcrops, though much less regular than the two just mentioned: the lofty summit of Blackdown, at its eastern extremity, is standing out like a promontory, about two miles beyond the other parts of the escarpment on the south of Hindhead. It is impossible not to connect these appearances with the general action of the force by which the whole of this country has been upheaved; all the features coinciding with the hypothesis of its elevation on a line or lines parallel to the axis of the forest ridge.

(55.) *Dorking to Leith Hill, &c.*—The tract between Leith Hill and Guildford affords nothing particularly deserving of notice, except the great height (993 feet) to which the outcrop of the lower green-sand rises, at the point on which the tower is placed. The space included between the escarp-

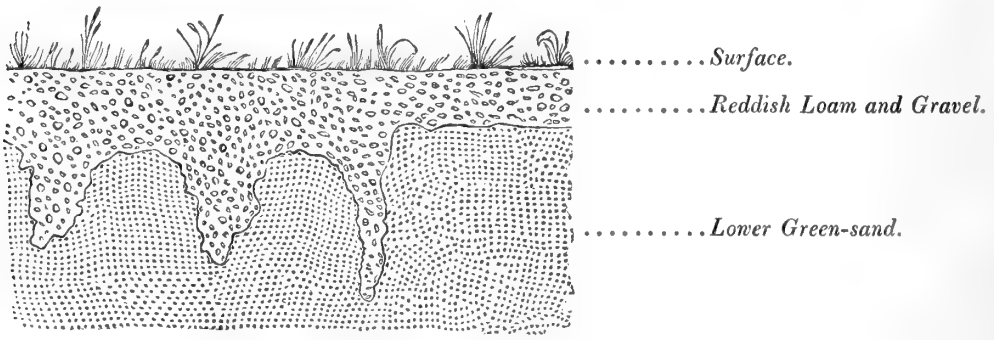
* To understand the structure of this country, the reader ought to have before him a map on a much larger scale than that in Plate IX., as Mr. Greenough's Map of England;—or the eighth sheet of the Ordnance Survey,—which, however, is by no means equal, in correct representation of the surface, to the more recent portions of that work.

† This stream has no name in the Ordnance map.

‡ Another anticlinal line, but in a direction oblique to that here mentioned, is indicated by the line of heights which runs from Milford, through Godalming, and thence by Unsted and Summersbury to Western Street, near Albury; the strata on the south-east of this line, near Godalming, dipping at a small angle to the south-east, obliquely from the range of the Chalk Downs.

ment and the downs from Dorking to Guildford is of nearly uniform character: but in approaching the latter place, the Lower green-sand rises with such rapidity, that Martha's Chapel equals or out-tops the chalk, though less than a mile distant from it horizontally. Slighter indications, also, of disturbance are evident throughout this tract. The lower marly chalk at Deerleap above Wotton is divided by smooth surfaces, produced by the sliding of large masses upon each other: and where the road rises from the mill towards Abinger Church, at a point which corresponds with a continuation of the ridge above mentioned, near Brastead and Sundridge, the beds are curved, so as clearly to indicate derangement.

(56.) The road west of Dorking, between Westgate Heath and the Rookery, is cut through the first beds of the Lower green-sand, the top of which is eroded into irregular cavities, resembling those which are found, throughout the south-east of England, on the surface of the chalk; and, like them, filled with reddish loam and fragments of chalk flints. This being one of many indications, on the margin of the great Wealden valley, that the agents, whatever they were, by which the chalk was excavated, acted in the same manner on the beds beneath it, and filled up the cavities with similar materials, at least as far down as the Lower green-sand.



The lower strata of the quarries near Cold Harbour, immediately under the tower at Leith Hill, are almost identical with those of Tilburstow, (p. 139); consisting of very green sand and soft sandrock, which alternate with chert, and include green matter, with white, vermicular or stem-like bodies, as at that place.

(57.) *Guildford, Godalming, Farnham, Hindhead.*—The tract on the south and west of Guildford, and thence to Hindhead, forms one of the most extensive surfaces of the Lower green-sand to be found in England; and the section from the heights on the north-west of Farnham to the Weald, (Plate X a., No. 4.) includes a succession of strata, from the Bagshot sands, one of the highest members of the English series, down to the Weald clay.

The quarries on the roadside between Guildford and Shalford, disclose a good section of the chalk, with numerous flints, dipping at an angle of about 5° or 6°, a little to the west of north; and on the opposite side of the Wey, beneath St. Catherine's Hill, the relative position of the lower strata is very well displayed.

(58.) *The Hog's-back.*—The remarkable ridge called the "Hog's-back," which runs from Guildford to a point about two miles from Farnham, has been produced evidently by an upthrow of the chalk, and the breaking off of the southern portion of the curve. The inclined position of the remaining side of the flexure is very well seen at the western extremity of a large chalk-pit between Guildford and Puttenham, where the strata dip towards the north, at an angle of about 30°. The upper beds are very white, with courses of the usual dark flint nodules; and a remarkable feature in this quarry, is the distinctness with which the chalk is divided into masses approaching to a rhomboidal figure, by seams oblique to the stratification; the angles of the portions thus bounded, standing out in the face of the cliff, like splinters in the shattered fracture of a crystal.

The Upper green-sand forms a slight projection along the foot of the Hog's-back; the Gault, a corresponding narrow depression along its whole length; and the Lower green-sand rises so rapidly beneath, that one or many inflections are necessary to account for its wide extent to the south. In approaching Farnham, the gault, near its contact with the sands, abounds in nodules containing a large proportion of phosphate of lime; resembling those of the vicinity of Folkstone (13.). The upper beds of the Lower green-sand rise, like the chalk, at a very high angle, and must have been bent suddenly in an opposite direction, since they are now continued, with a moderate inclination, several miles to the south. Along the north of Puttenham Common, the sand is reddish, and very like that of Red-cliff at Sandown Bay, in the Isle of Wight. A nearly continuous surface of the sands extends towards the south from Compton to Hurtmore, and North Brook Place, and is resumed on the south of the river, through Westbrook and Upper Eashing. It is again cut through by the stream, which the London road accompanies, on the south-west of Godalming; but recurs, in the heights south-east of the town, from Holloway-hill and Crown Pit to Munstead Heath, which seems to be nearly on a level with the top of the Hog's-back. On the west, the upper beds of sand form several prominences, among which Crooksbury-hill is the most conspicuous; their elevation having probably been the effect of protrusion. On the south-west of Crooksbury, the upper sands seem to expand, and to occupy a still wider horizontal space in that part of the denudation which corresponds to the less inclined beds about Farnham.

(59.) The general thickness of Lower green-sand here seems to be nearly the same with that of the coast, and may be taken as between 350 and 400 feet; though, from its superficial extent, a much greater thickness might be ascribed to it, if the disturbance and inflexion which it has undergone were not kept in view. There can be no doubt, both from the features of the

surface, and the hue and texture of the strata, that the subdivision into three, which is conspicuous near Folkstone, and not much less distinct in Western Sussex, exists also in this tract. But the precise boundaries of these groups are by no means obvious, for there are not hereabouts those characteristic beds of stone, which are found near the coast; their place being supplied, in the uppermost group, by concretions of a coarse conglomerate, which in the country bears the name of "Bargate Stone*;" and, in the lowest group, by chert and indurated sandrock, like those of Leith and Tilburstow hills. This comparative scarcity of calcareous matter is one of the principal differences between the eastern and western tracts of this formation.

The more ferruginous concretions, (the "carstone" of Norfolk,) which are very abundant in the upper part of the Lower green-sand of this neighbourhood, are often so compact as to ring under the hammer, and are thence called "clinkers" by the quarrymen; sometimes forming plates or flakes, a quarter of an inch and upwards in thickness, and curved so as to resemble portions of concentric layers of petrified trees. This stone furnishes an excellent material for the roads, and gives a remarkable reddish hue to some of those which are macadamised in this country. Fragments of brown hematite also, like those of the Red-cliff near Culver in the Isle of Wight, are found at many places in this vicinity; as at Thursley, &c.

(60.) *Godalming.*—The heights about Godalming afford excellent sections, which may with some probability be assigned to the lowest part of the Green-sand formation. The order in general was thus :—

Holloway-Hill, Godalming.

	Feet.	In.
1. Green and variegated sand, abounding in large concretions of chert, and of calcareous conglomerate, ("Bargate-stone;") which is hard and sparry, and in some places passes into chert. It contains traces of shells and of alcyonic stems. False stratification is here remarkable; the concretions also following the oblique or false lines.....	about 15	0
Some of the larger masses of this rock are precisely like the concretions on the shore near Folkstone (20.);—a very compact sparry variety of "Kentish-rag." In the upper sands of Polstead, near Puttenham, irregular concretions of this compound occur, imbedded in soft sandrock, and containing carbonate of lime in rhombs.		
2. Sand, of the same kind, without concretions; but including thin beds of a tough clay, like Fuller's-earth.†.....	about 25	0
The dip here is towards the south of east, and all the summits are flat and uniform.		

* The origin of this term is somewhat doubtful. A place called "Burgh-gate," from whence it may have been derived, occurs in the Ordnance Map, on the south of the escarpment between Hambleton and Hascombe.

† The Fuller's-earth would refer these strata to the lowest division of the sands. Thin beds of that mineral, however, are found throughout this formation.

Among the looser sandy materials of Holloway-hill are spongy concretions, which show, when moist, the same vermicular structure as at Tilburstow-hill.

Blackheath, south-east of Guildford, seems to have been once a continuation of the sands near Godalming. Its top is nearly level with the chalk range, but lower than Martha's Chapel hill. On the south, the ground descends to Farley Heath, with a sort of escarpment like that of Crooksbury and Farnham commons, hereafter mentioned; and the road thence by Farley-green to Hound-house is in a richer sand, supporting pools in several places, and probably belonging to the middle group.

Crooksbury Common seems to consist of the upper members of the formation, impending, like an outcrop 150 to 200 feet thick, over the valley of the Wey, between Elstead and Tilford; and on the south of the stream the heights of sand are renewed. Farnham Common is analogous to that of Crooksbury, and apparently a continuation of the same plateau, deeply cut through by one of the principal streams of the Wey. On the south of these, is the lower tract of Frensham and Thursley commons, and thence the ground rises rapidly towards Hindhead, the ascent consisting of sand deeply trenched into channels. A conspicuous group of barren, somewhat conical hills, on the south of Frensham Common, called the "Devil's Jumps," is apparently the remaining portion of a stratum of sand reduced by abrasion to the present irregular form; and the pebbles and rolled masses on Thursley Common, immediately on the north of Hindhead, are sandrock, passing into chert, which seems to be unmixed with other matter, and to be the debris of the beds now removed.

(61.) *Hindhead.*—The crest of Hindhead is on the north-east of a depression called the "Devil's Punchbowl," round which the road is conducted. The highest part of the curve, or anticlinal bending, of the Lower greensand, seems to be just at a point where the new road, on a lower level than the old, has exposed a face of 10 to 25 feet in height. The flexure is very slight, but sufficiently perceptible, occurring in such a place, to be deserving of notice. The strata consist of soft sandrock, containing concretions, and nearly continuous beds of chert, passing into chalcedony, of various shades of yellow and brown; with occasional layers of bright yellowish sand, in which the lines of false stratification are conspicuous. All over Gray-shot Down the subsoil is a soft, loose sand of the same description.

(62.) The whole of the tract here occupied by the sands, though not unpicturesque, is wild and barren in its aspect, destitute of wood, producing only ferns, heath, and furze. The surface is in fact, to this hour, nearly such as it may be conceived to have been when first uncovered by the departure of the sea; and its structure is just what may be imagined to result from the levelling effect of water under the influence of motion of no great violence. In crossing this desolate region by the main road from London to Portsmouth, it is difficult to believe that we are only forty miles distant from the capital, and midway to one of the chief naval establishments of the empire: but the nature of the soil effectually prevents improvement, and it is not improbable that this tract may remain for centuries

unchanged, and still exemplify the power of geological causes in modifying the civil condition of countries, as well as their external features.

In the bottom of the "Punch Bowl," perhaps 200 feet beneath the road, a small stream arises, and the north flank of the highest ridge of Hindhead, which runs nearly west from the summit, is furrowed by nine or ten similar and nearly parallel trenches: the deepest of these is called Hackham Bottom, the stream from which is continued along the verge of Thursley Common to the Wey at Elstead. The ridge represented in the section No. 4. is that of Grayshot Down, as it appears from the lower ground on the north. It declines westward to Harem, and also to the south; so that there is here distinctly an anticlinal line, more than three miles north of the central valley of the Weald between Ludgershall and Harting-combe.

(63.) Although Hindhead is the most prominent point in this part of the country, it is not, strictly speaking, the escarpment of the Lower green-sand; for the strata, which rise very gradually on the west of the denudation, run out to the east beyond the highest summit, and caps of sand are preserved on some of the advanced ridges and in several detached points. For the same reason, Blackdown Hill, about four miles south of Hindhead, is no more than a massive cap of sand, resting with a very slight inclination upon the Weald clay: and all the deep ravines which separate the heights and ridges on the west and north-west of Blackdown, towards Lynchmere and Haslemere, have sand only at top; the clay rising here to not much less than six hundred feet above the sea. Blackdown forms the north-eastern promontory of what may be called the central valley of the denudation; the opposite and converging side of which is a similar escarpment of the Lower green-sand, extending from Harting-combe to Bexley-hill. The floor of the narrow intermediate space consists of the Weald clay, which, close to the junction, abounds in *Cypris Faba*; and where the valley opens into the wider expanse of the Wealds, the first range of the Wealden sand and sandrock, described by Mr. Martin, about 25 feet thick, and at a vertical distance of about 200 feet from the top of the clay, forms a sort of bar, or elevated ridge, across the entrance; occupying an extensive surface between Ludgershall upon the Lod, and Northhurst, and being thence continued, at a corresponding distance from the top of the clay, all round the denudation. The course of the Lower green-sands on the south and south-west of this valley having been pointed out by Mr. Murchison, it is unnecessary to pursue this description farther.

(64.) *Weald Clay.*—The lowest beds of the tract near Guildford have recently been exposed in a pit for the extraction of gravel at Pease-marsh, an extensive flat on both sides of the London road, between Arlington, south of Guildford, and Godalming. On examining the place, to which my attention was called by Mr. Murchison, I found beneath a thickness of four or five feet of flint gravel and sand, distinct strata of blue clay,

nearly horizontal, though with an irregular surface, including flat nodular concretions of iron pyrites, also horizontally disposed. No fossils were visible; but from the situation and characters of the clay, it seemed most probably to be that of the Weald, brought up into this close proximity to the chalk, by the general elevation of all the strata. It is indeed probable that the Weald clay is very near the surface in many other places; but as the middle group of the sands is also retentive of water, and capable of sustaining ponds, the distinction can be ascertained only by attention to local circumstances. The difference of level is so small in the different portions of the Wey, from Pease-marsh, by Godalming, Pepperharrow, Elstead, and Tilford, that this clay may be the base of the stream throughout; but many of the ponds which occur at higher levels, in the tract between Dorking and West Sussex, may safely be referred to the middle group of the sands *.

(65.) *Tucksbury-hill*†, *&c.*—The summit of this hill, which forms the northern extremity of the section, Plate X. a. No. 4. is an outlier composed of siliceous and ferruginous sand, upon the surface of which are numerous angular fragments of pale yellowish flint. The ground descends from it on all sides, but with the greatest rapidity towards the valley of the Wey; and it affords an excellent view, both of the successive outcrop of the strata in the lower country, on the south-east, and (especially) of the tract on the north, occupied by the Bagshot sands‡, to which the cap of the hill seems to belong; the flat-topped ranges and the lower barren tracts of that formation being seen from hence very distinctly. The summits of Romping-down and Chobham-ridge project above the surrounding country, with escarpments towards the east, nearly at right angles to the range of the Chalk Downs; but the general rise of the sands is towards the south, conformably to that of the chalk §. The succession of strata observable in

* Such are probably the ponds of Berry-hill, Lonesome, Wotton, and Abinger, near Dorking; of Thorncombe-street, Wormley-heath, Witley, and Lea-house, near Godalming; Frensham Great Pond; and many of the pieces of water in Woolmer Forest. Several of the ponds near Pulborough can with certainty be referred to the geological place mentioned in the text.

† This name of the hill is taken from the Memoir connected with Mr. Greenough's map. In the Ordnance map, one point on the summit is called *Farnham Beacon.*

‡ Warburton: in Geol. Trans., 2nd Series, vol. i. page 48.

§ I had proof of this rise, in passing along the main road from Guildford. At an early hour of the morning, in October, all the flat country on the north was occupied by a dense uniform fog, which filled the inequalities at the foot of the sand-heights on every side. Above this sea or lake of mist, which afforded a sort of fluid level, the tops only of the ridges were visible, like long dark islands, the southern extremities of which were uniformly higher than the northern; the intermediate line declining at a very small but perceptible angle.

descending from the elevation to the valley of the Wealds, is very instructive.

At the west end of the hill, beneath Warren's-corner, on the road to Basingstoke, Septaria are found in a stratum of the London clay, which occupies a considerable thickness on the slope of the hill, below the cap of sand. I was informed that "Pot-earth," of a different quality, occurs lower down, in Clarehouse-Park, in the situation of the Plastic clay; and I have seen the Chalk in the decline of the hill, between Lower Old Park and Halfway-house.

The Upper green-sand forms a slight prominence beneath this chalk, on the south of Dippenhall-house, between the words 'Dean's-farm' and 'Ridgway' on the Ordnance map, the strata dipping not much more than 5° to the north. The rock, which is there called 'Marl-stone,' does not precisely agree with any I have seen between this place and the coast, but is very like some of the strata in the corresponding place at East Knoyle, on the north of the Vale of Wardour. It is a subcalcareous sandstone, or variety of "fire-stone," very soft, uniform, of a yellowish-grey or cream-colour, scarcely effervescent, and remarkable for its lightness; and it includes concretions of a hard splintery limestone, approaching to chert, and of much greater density than the stone which surrounds them.

The Gault, on the line of the section, first comes up on the road descending from Ridgway to the river Wey, but is more distinctly seen at the extremity of Wracklesham; and, in consequence of the more gradual rise of the strata, on the south-west of that village, it occupies a more expanded surface in Alice-Holt Wood, as described in Mr. Murchison's paper above referred to.

On the south of the main London road, where it is crossed by the road to Wracklesham, is a bank with the Lower green-sand at the bottom, rising towards the village. The surface is waved remarkably; and the inequalities are filled up with gravel, consisting of broken flint pebbles, in large proportion, mixed with red loam, and in immediate contact with the yellowish sands below. The top of the gravel, is nearly level; but its depth to the sand varies from $1\frac{1}{2}$ to 4 feet. This fact is analogous to the erosion of the sands near Dorking, mentioned above (56).

(66.) The mode in which the drainage of the north-western portion of the great valley of the Wealden is effected, and the different manner in which the streams escape, in this part of the country, from that of their egress through the North and South Downs, support the hypothesis of Mr. Scrope and Mr. Martin, that the gorges themselves were not produced by simple denudation, but at least prepared, by antecedent fissures cutting entirely across the Weald: while the appearances of the surface, above described, are so unlike those which would have been produced by rapid diluvial action, as to indicate either a long period of submersion, at no great depth, or very gradual drainage and long-continued decay.

The principal branch of the Wey, from its rise near Alton, to Farnham, is nearly straight, in a direction from south-west to north-east; but immediately below Farnham, instead of cutting across the chalk downs, it turns abruptly to the south-east, to join another branch; which likewise runs in a straight line nearly parallel to the former, from its source in the chalk near Selborne, through Kingsley, by Frensham, to Tilford Bridge, where the streams unite: and then taking a tortuous course, but in a general direction parallel to the Hog's-back, the river cuts deep

through the platform of the sands, on the north and west of Godalming, receiving several streamlets by the way. But there, instead of continuing its direction, it turns suddenly to the north; and receiving another branch from beyond Cranley, far within the valley of the Wealds, cuts almost directly across both the green-sand and the chalk, and makes its way to the Thames at Weybridge. The mere closing-up of the defile at the mills on the north of Godalming, would convert the whole of Pease-marsh, Frensham, and Thursley commons into a lake:—and, on the other hand, a slight excavation towards the north, through Frensham to the river, would drain the great pond there.

The sudden change in the direction of the Wey, near Farnham, is the more remarkable, as the Blackwater, which rises on the northern slope of the chalk downs between Farnham and Aldershot, about two miles from the angle of the Wey near the west end of the Hog's-back, runs on the Bagshot sands, towards the north and west, by Frimley, Blackwater, &c., to join the Lodden, not far north of Strathfieldsay, in its course to the Thames near Shiplake. The line of the Wey, therefore, from Alton to Farnham, is nearly a continuation of that of the Blackwater*; the two streams being separated only by the prominence of the chalk between the Hog's-back and the foot of Tucksbury Hill†.

The gorge of the Wey is nearly opposite to that of the Arun, on the south of the Wealden, one branch of which runs almost directly north and south, from a point between Loxwood and Slinfold, to the sea at Little Hampton; and the structure of the two rivers is very much alike. The Arun rises in the centre of the Wealden tract, whence it runs directly to the sea; as does the Wey from Cranley: but it receives, near Pulborough, at right angles to the main stream, the copious branch (if it be not rather itself the principal stream,) called the Rother; which, having risen near the ponds of Wolmer Forest, very near the sources of the Wey, and followed the curves of the denudation for more than twenty miles, in the trough between the chalk escarpment and the Lower green-sand, is then carried suddenly out of that direction, and withdrawn from the valley of the Weald.

(67.) From whatever cause the transverse course of the streams may have originated, the relative composition of the strata was favourable to their retaining that direction, when once they had made their way across the chalk and Upper green-sand. For, as the lower beds of the chalk itself, and still more the Gault, are remarkably retentive, while the upper chalk is permeable by water,—the slope of all the strata being outwards, or from the central ridge of the valley, the whole of the waters imbibed by the chalk would be determined outwards, if any pervious channel were opened at its bottom. And if a fissure were cut through the whole series, without great vertical displacement, the retentive beds of the chalk-marl and clay, would immediately reunite, and close it below; while, the chasm in the chalk above remaining open, a permanent drainage outwards would be produced, and the break would be continually enlarged.

* The main stream of the Wey is that which runs direct from Wolmer to Shalford. See the map.

† It should, however, be kept in view, that the bed of the Blackwater hereabouts is several feet above that of the Wey.

(68.) The following is a list of some of the fossils obtained from the strata above the Weald clay, within the portions of Kent and Surrey mentioned in the preceding sections (37. to 67.):—

List of Fossils of the Gault and Green-sands, in the INTERIOR OF KENT, *and part of* SURREY.

Ammonites dentatus. Gault. Brick-field near Westerham. F.

A——— lautus. Gault. Same place. F.

A——— splendens. Gault. Bletchingley, Surrey. Mantell.

A——— tuberculatus. Gault. Brick-field near Westerham. F.

A——— ? A fragment of a very large Ammonite (or Hamite?), was found by one of my sons (W. I. F.), among the lowest beds of the green-sand on the south of Brasted in Kent; which, when complete, must have formed a spiral between two and three feet in diameter. The separate convolutions are about nine inches in breadth; and the flutings of the surface, which are simple, are about two inches across the broadest part, and in depth about an inch. The specimen belongs, not improbably, to one of the large species which occur in the Gault of Yorkshire, (see Phillips).

A———. Four species occur at Boughton quarries.*

Ampullaria canaliculata. Gault. Bletchingley, Surrey. Mantell.

Belemnites minimus. Gault. Bletchingley. Mantell.

B———. A large species. Boughton quarries. Also at Cold Harbour, near Montreal Park, Sevenoaks, Kent. F.

Cucullæa. (Species doubtful.) Lower green-sand. Boughton quarries. F.

Dentalium decussatum. Gault. Brick-field near Westerham. F.

Exogyra conica. Boughton. F.

E——— lævigata. Boughton quarries. F.

Fistulana. (Species doubtful.) Ditto. F.

Gervillia. (Species doubtful.) Boughton. F.

Gryphæa sinuata. Boughton. Also near Brasted; West Kent. F.

Inoceramus concentricus. Gault. Brick-field near Westerham. F.

I——— latus. In a fragment of yellow quartzose chert, loose on the surface, near Brasted, Kent. F.

Modiola parallela. Lower green-sand; Near Maidstone. M. C.

Mya. (Species doubtful.) Boughton quarries. F.

Nautilus elegans. Boughton. F.

Nucula pectinata. Gault. Brick-field near Westerham. F.

Pecten quinquecostatus. Lowest green-sand. Riverhill. G.

Pholadomya. (Species doubtful.) Boughton. F.

* All the specimens from Boughton were found in the Lower green-sand: the greater part in the soft grey calcareous rock, full of green particles, called "Hassock."

Plagiostoma. A small species. Lowest beds of the green-sand: Riverhill, near Sevenoaks. Mr. Goodhall.
Pleurotomaria striata*. Pl. XIV. f. 16. Boughton. F.
Plicatula pectinoides. Boughton. F.
Rostellaria carinata. Gault. Bletchingley. Mantell.
Serpula. Boughton. F.
Sphæra corrugata. Lowest green-sand. Trevereux, near Lympsfield, Surrey. F.
Terebratula Gibbsiana. Boughton. F.
T———— oblonga. Lower green-sand. Riverhill. G.
Thetis major? Boughton. F.
Trigonia alæformis. With two or more other species. Boughton. F.
Turbinolia Kœnigii. Gault. Bletchingley. Mantell.
Venus angulata? (Cyprina.) Large, flat. Boughton. F.

Wood, Dicotyledonous. Boughton; and near Brasted, West Kent. F.

Hyæna. Portions of the bones of the extremities of this animal, and fragments of the skull and teeth, both molar and canine, with pieces of Album Græcum, have been found imbedded in brownish sandy loam, at the top of the quarries of Boughton Mount. F.

Iguanodon. Distinct remains of this reptile, found by Mr. Binstead in the Lower green-sand at Rockhill, near Maidstone, have been examined and described by Mr. Mantell. See note on (38).

Hampshire and Western Sussex.

The south-western portion of the Wealden denudation has been so fully described by Mr. Murchison and Mr. Martin, that I shall refer to their publications already quoted, for an account of it; giving here only some additional facts with which I have been favoured by those two gentlemen: and for a similar reason I shall leave untouched the territory of Mr. Mantell in Western Sussex.

(69.) *Hampshire.*—Accumulations of broken chalk flints have been found very extensively, over the surface of the Lower green-sand, on the new road from Petersfield to Midhurst in West Sussex; at Sheet Hill; and several other places in this part of Hampshire. In the former situation, which is about three miles from the nearest chalk, the detritus covers an uneven surface of the sand, which appears to have been acted upon precisely in the same manner as that

* In the list of the fossils of the vicinity of Folkstone (p. 131.), this shell has been called a *Trochus*: but a very fine specimen obtained from Kent, and kindly mentioned to me by Mr. Charles Manning, has since convinced Mr. Sowerby that the true genus is Pleurotomaria. See the descriptions of the new species, in the Appendix.

of the chalk itself; the sand being eroded into irregular cavities, sometimes almost tubular, which are now occupied by chalk flints, a great part of them in small fragments, and all of a rusty yellow colour. Equally abundant accumulations of these are seen also on the hills of white sand (one of the upper members of the Lower green), at Stedham and Trotton commons, between six and seven miles east of Petersfield; but in this case the flints are not discoloured. This latter place is distant nearly three miles from the nearest point of the chalk, and between nine and ten miles east of that where the chalk escarpments are confluent. In the angle of the chalk west and north-west of Petersfield, particularly in the ascent to Alton by Stoner Hill, such heaps are yet more common. These facts coincide with the observations already mentioned, near Boughton, Dorking, and Wracklesham (38, 56, and 65); so that it would seem as if chalk flint gravel above the Lower green-sand was of general and frequent occurrence all around the denudation. Mr. Murchison, however, adds, that he has still no knowledge of any such debris beyond the limits of that formation, or within the Wealden properly so called.

(70.) The stiff and retentive marly beds, at the base of the Downs, sustaining the water which descends through the chalk, have produced a line of ponds along the bottom of the escarpment of the South Downs;—a result precisely analogous to the breaking-out of the springs above the marl, at Lydden Spout, upon the coast (8.), and all along the base of the Downs on the north.

(71.) One of the chief characteristics of the tract near Petersfield, consists in the great relative extent and prominence of the Upper green-sand; which runs out beyond the foot of the chalk escarpment, like a step or terrace, throughout the tract from Farnham, by Selborne and Petersfield, to the south of Petworth, and affords some of the best sections anywhere to be found, except perhaps in the Isle of Wight. Though in the parishes of Buriton, Harting, &c., there is an insensible passage from the grey chalk and chalk marl, into the Upper green-sand, still the *whole* of the terraces (there at least two miles broad) are exclusively composed of what is called in the country *Malm-rock**. The grey or lower chalk of this portion of the South Downs is charged with the *Inoceramus mytiloides, I. Cuvieri, I. Brongniarti,* and two species of small plicated Terebratula, and does not contain any of the characteristic malm-rock fossils enumerated in Mr. Murchison's memoir; nor does the malm-rock contain, so far as his observation goes, a single specimen of the genera Inoceramus and Terebratula, so abundant in the overlying

* The *Malm-land*, which is remarkable for the fine crops of corn produced upon it, is, properly, the soil over the lowest beds of marly chalk, which are carried out upon the tops of the projecting terraces; the term, "*Malm-rock*," being confined to the stony beds beneath.

chalk: a fact which is the more deserving of attention, as several other genera and species are found both in the Upper green-sand and the Lower chalk*.

(72.) *Vicinity of Pulborough.*—I am indebted to Mr. Martin for the section (Plate X a. No. 5.) across the Wealden district, from Duncton Beacon on the South Downs, through Petworth, to Cranley; and I have, from my own observations, continued it in the same direction to the North Downs. This section shows, what Mr. Martin's recent observations have fully confirmed, that the subdivisions of the sands below the chalk, in the north-west of Sussex, correspond with those above described, in the neighbourhood of Folkstone; and that a similar valley distinctly marks, in both cases, the place of the middle greener and retentive sands, (24.). I have had myself also an opportunity of seeing, with Mr. Martin, a section parallel to that of Plate X a., in which this structure is very clearly displayed, on a line about half a mile west of Pulborough, passing through the heights of Park-hill farm and Pethenden (with the valley of the middle sands between), to a detached summit within the Weald-clay, called Pickhurst Hill; (See Plate X b. fig. 2.). Fuller's-earth like that of Nutfield, appears at Fittleworth Church, near Pulborough.

Besides the mass of this intermediate group, a detached stratum, about 40 feet in thickness, of dark-coloured, greenish grey, retentive sand, including much pyritous matter, occurs above it, with some feet of ferruginous and yellowish sand between;—a subordinate bed, in fact, *within* the upper ferruginous mass of the sand: and this ought to be held in view, as in some cases it might be mistaken for the Gault. It is very conspicuous on the ascent of the London road, from the flats on the south, to the church at Pulborough; and can be traced thence, almost continuously, for some miles both to the east and west. No fossils have been found in this stratum, except some impressions of what may be the branches of fuci. A bed of dark hue, with the same characters, seems to occupy a corresponding place in the series near Reigate: See note † on (52.).

(73.) This country has been the scene of several upheavings and derangements of the strata, analogous to those above mentioned in West Kent (41. to 43.), but much more complex and extensive. Some of these have been described in Mr. Martin's work already referred to; and of others, more recently observed by that gentleman, I hope he will himself soon publish a description‡.

* See Mantell's "Tabular Arrangement of the Organic Remains of Sussex"—Geol. Trans. 2nd Series, vol. iii. p. 210. Terebratulæ are there mentioned among the genera common to both deposits.

‡ The forces by which such derangements may have been effected, appear to be still in action in this part of England. In the spring of the present year, 1834, distinct shocks of an earthquake were felt throughout a tract, of which Chichester seems to have been the principal point. At Pulborough, they were of such force as to ring the bells at the parsonage. An account of the phenomena, is, I believe, in preparation, by some members of the Philosophical Institution at Chichester.

(74.) The junction of the sands and clay, at Stopham brick-yard, on the west of Harwood's Green, near Pulborough, affords the only indications that have come to my knowledge, of any interruption or disturbance between the deposition of the upper part of the Weald clay, and of the incumbent Lower green-sand. The surface of the clay at the place in question is hollowed into irregular roundish cavities, at the bottom of which portions of green-sand were found, including several of the characteristic fossils of that formation; while the clay, immediately below, is equally characterized by the presence of Cypris. At the junction, the clay was mixed with sand; and specimens of *Panopæa plicata* were found even two or three feet within nearly pure clay, along with ferruginous concretions, containing fossils of the Wealden, impressions of Cyclas, Cypris, and remains of fishes: and this mixture was observable to the depth of several feet;—so that both the sand and clay must have been at the time of mixture in a state of softness; or the sand must have been introduced over a surface of argillaceous mud, before it had consolidated. When I had the pleasure of examining the place, with Mr. Martin, the circumstances were unfavourable to observation: and, as the junction of the two formations here, is on the slope of a hill, it might have been doubted whether the appearances could not be explained by the effects of subsidence producing intermixture, during very rainy weather, or under water, before any of the strata had emerged. Mr. Martin, however, who had seen the place when the phenomena were better exhibited, is of opinion that this explanation of them would not have sufficed. In this brick-yard, the loamy sand found near the junction is used *alone* for making the bricks; sand being required in the manufacture, only for sprinkling the moulds.

(75.) *List of Fossils from the Beds below the Chalk, in part of Hampshire and Western Sussex.*

[*Upper Green-sand.*]

The following List of Fossils from the Upper green-sand in the vicinity of Petersfield, in addition to those mentioned in Mr. Murchison's paper on that district, (Geol. Trans. 2nd Series, vol. ii. p. 99.) I owe to the kindness of Mrs. Murchison, in whose collection the specimens are placed.

Ammonites catillus.
A——— *splendens.*
Arca carinata.
Avicula gryphæoides. (See Pl. XI. f. 3.)
Cucullæa. Much compressed.
Echino-spatangus. (Three new species.)
Fishes. Scales and vertebræ.
Gryphæa columba.
G——— *vesiculosa.*
G——— *sinuata.*
Nautilus elegans ?? Much compressed.
Pecten asper.

Pecten Beaveri.
P—— nitidus.
P—— orbicularis.
P—— quinquecostatus. Besides one or two other species, indistinct.
Plicatula inflata.
Solarium granulatum. Mantell.
S—— or *Trochus.* Another species.
Thetis major.
Vegetable impressions. Like those of the upper chalk near Lewes. Mantell, t. 9. p. 157.

[*Lower Green-sand.*]

Ammonites dentatus. Stopham brick-yard, West of Pulborough, Sussex; in a mass of phosphate of lime. This, with the other fossils from the same place, was found by Mr. Martin covered by green-sand, in an excavation at the top of the Weald clay. Martin MSS.

A———. (Near to *Nutfieldiensis*, but a distinct species.) Lowest member of the sands near Pulborough: Martin.

A———. (Impressions of one or two other species.) Stopham brick-yard: Martin MSS. One of these is in a roundish mass of phosphate of lime, precisely like specimens found near Copt Point, Kent: the outer surface is whitish, and is eroded in small tortuous grooves, as if eaten by worms: the interior brown.

Auricula (new species). Martin, *ibid.*

Avicula? Martin, *ibid.*

Cardium? (New species; delicately striated.) Stopham brick-yard: Martin MSS.

Coprolite. Stopham brick-yard: Martin MSS.

Corbula gigantea. Bowyer's Common: Mrs. Murchison.

C—— striatula. Bowyer's Common, near Petersfield: Mrs. Murchison. Parham: Mantell, and Martin.

C—— (new). Near Pulborough: Martin, p. 32.

Crustacea. "At Bognor Common, in Fittleworth parish, there is a vein of friable "green-stone, rich in Pectens, Trigoniæ, and the remains of a crustaceous fossil "like a shrimp." Martin, p. 34, note.

Cucullæa decussata. Parham: Mantell, and Martin.

C——— glabra? Bowyer's Common: Mrs. Murchison.

C———. (Another species—or two?) Stopham brick-yard: Martin MSS.

Cyprina angulata. (*Venus*, Min. Con.) Stopham: Martin MSS.

Cytherea parva. (*Venus*, Min. Con.) Parham: Mantell. Bowyer's Common, and Lyss near Petersfield: Mrs. Murchison. Upper ferruginous member of the Lower green-sand, Pulborough Mount: Martin MSS.

Gervillia acuta. Parham: Mantell.

G——— aviculoides. Parham Park: In concreted masses of fine-grained ferruginous sand, with several other species mentioned below; all casts: Martin. Also Bowyer's Common: Mrs. Murchison.

G——— solenoides. Parham: Mantell.

G———. (Another species, probably new.) Upper ferruginous member of the sands: Martin.

Inoceramus gryphæoides. Lowest group of lower green-sand: Martin, p. 33.

Lima semisulcata. Plate XI. fig. 10. Pulborough: Martin.

Lucina? Bowyer's Common: Mrs. Murchison.

L——. (Perhaps two species.) Lowest member of the sands; near Pulborough: Martin.

Modiola æqualis.
M—— *bipartita.* } Parham: Mantell.

M—— *imbricata.* Upper ferruginous sands: Mantell, and Martin.

M—— bella. Plate XI. fig. 9.

M——. (A new species.) Near Pulborough: Martin, p. 32.

Mya mandibula. Lowest member of the sands. Pulborough: Martin.

M— *plicata.* (See *Panopæa plicata*).

M—. (Two species not figured.) Martin, p. 33. Lowest group of lower green-sand.

Mytilus edentulus? Martin, p. 32.

M—— *lanceolatus.* Parham: Mantell.

Natica. Parham: Parkinson; Organic Remains, vol. 3. Pl. 6. fig. 2. Lyss near Petersfield: Mrs. Murchison.

Nautilus. Near Pulborough: Martin, p. 31.

Nucula impressa. Parham: Mantell. Lowest member of the sands; Pulborough: Martin.

N—— *antiquata.* Upper ferruginous member of the Lower green-sand; Pulborough Mount: Martin.

Orbicula. (Not figured.) In sand rock: lowest member of the sands; Pulborough and Stopham: Martin.

Panopæa plicata. Lower member of the sands; Parham Park, and Stopham brick-yard: Martin MSS.

Patella. Parham: Mantell.

Pecten obliquus. Parham: Mantell, and Martin.

P—— *orbicularis.* Pulborough: Martin. Parham: Mantell.

P—— *quadricostatus.* Parham: Mantell.

P——. (A new species.) Martin.

Pholadomya. Lowest member of the sand near Pulborough: Martin, p. 32. and MSS.

Pinna tetragona. In sand-rock; lowest member of the sands: Martin.

P——. (A cast.) Stopham brick-yard: Martin.

Rostellaria calcarata. Parham: Mantell.

R——— *Parkinsonii.* Parham: Mantell. Upper member of the sands; Pulborough Mount: Martin.

R———. (Very like *Pes Pelicani.*) Parham: Mantell.

Tellina æqualis.
T—— *inæqualis.* } Parham: Mantell, and Martin.

T——? (A species not figured.) Lowest member of the sands, near Pulborough: Martin.

Terebratula lata.
T——— *ovata.* } Parham: Mantell.

Terebratula nuciformis. Upper member of the sands; Pulborough Mount: Martin.
T.——— depressa. Upper ferruginous member of the Lower green-sand; Pulborough Mount: Martin MSS.
T———. (Another species—uncertain.) Same place: Martin.
Thetis major. Lowest member of the sands; Pulborough: Martin.
T.—— minor. Bowyer's Common, and Lyss, near Petersfield: Mrs. Murchison. Parham: Mantell. Upper member of the sands; Pulborough Mount: Martin.
T.—— (new). Stopham brick-yard. Martin MSS.
Trigonia alæformis. } Bowyer's Common: Mrs. Murchison. Parham: Mantell. Stop-
T.——— clavellata? } ham: Martin.
T.——— dedalæa. Parham: Mantell.
T.——— spinosa. Pulborough: Martin, p. 33.
Turbo rotundatus. Parham: Martin MSS.
T.——. (Another species.) Near Pulborough: Martin, p. 31.
Turritella granulata. Parham, and Pulborough: Martin MSS.
T.———. (Another species.) Near Pulborough: Martin MSS.
Venus angulata. See *Cyprina.*
V.—— Faba. } Parham: Mantell.
V.—— ovalis. }
V.—— parva. See *Cytherea parva.*
V.——. (Casts of two other species.) Stopham: Martin MSS.
Vermicularia concava. Parham-park, Parkmount-lane near Pulborough, Chiltington-common. Martin, pp. 33 and 34.

The Wealden.

(76.) In adopting this general denomination, proposed by Mr. Martin, for the formations below the green-sand, in the Wealds of Kent, Surrey, and Sussex, I have extended its acceptation to the Purbeck strata also, which do not occur within those counties; because the whole group abounds in fossils of the same character. And though the Purbeck strata consist principally of limestone, which has many indications of lacustrine origin, they include, like the upper members of the Wealden, distinct alternations of marine fossils with those of freshwater:—one very thick bed especially, which consists almost entirely of oysters,* showing that the sea must have had access to the waters from which they were deposited. Mr. Martin has ascertained that the Wealden strata above the Purbeck, consist, throughout, of alternations of sand, sand-rock, and grit, with clay and marl; so that the separation of the Weald-clay from the Hastings sands, is in a great measure arbitrary. But as in the only tracts where this group has yet been observed, the sands rise above the valley of the clay, into a very prominent ridge, which forms a striking fea-

* Webster: Geol. Trans., 2nd Series, Vol. II., p. 40.

ture of the surface, this subdivision is to a certain extent natural, and may be retained with advantage.

(77.) *Valley of the Wealds.*—The beds of sand, sand-rock, and limestone subordinate to the Weald clay, have been traced by Mr. Martin throughout the tract represented in his map of Western Sussex, and I refer to his memoir for an account of them: their place is indicated in the Section, Pl. X. a. fig. 5. I have myself observed beds of the same description,—no doubt continuous with those described by Mr. Martin, though I have not traced their continuity, on the opposite side of the Wealden and of the forest ridge, about Ewhurst, and on the east of that village*. And in the course of the valley eastward, through Surrey and Kent, distinct and almost continuous ridges, apparently produced by the greater durability and prominence of similar strata, are observable from the escarpment of the sands, and are in part expressed in the Ordnance Maps.

Two, if not three lines of these subordinate strata cross the road which descends from the escarpment of the sands through Ewhurst. 1. The first is at the foot of a height, which runs from the south of Coneyhurst Farm, through Woodland; the beds consisting of limestone, (Sussex marble) full of large Paludinæ and Cypris. A group, possibly a continuation of this, occurs in Mr. Turner's grounds, north of Forest Green, at Atherley, about two miles east of Woodland, below Leith-hill Place; but there the stone is greenish micaceous grit, in three contiguous courses, each about 12 inches thick, containing very large Paludinæ, Uniones, and stemlike concretions, where the stone adjoins the whitish sand, on which it rests. Above Henhouse Farm also, about a mile and a half east of Atherley, a range of high ground indicates the presence of firm bands of stone; and grit is found there, which includes similar Uniones, and a few Paludinæ. 2. A second band, composed of ironshot sand, over variegated reddish brown clay, crosses the road, at the church of Ewhurst, passing thence eastward through Lyefield Farm. The stone-pits of Forest Green seem to be on this line, but they consist of beds of grit including Uniones and Cypris, above yellowish sand, reddish clay, and concretional sandstone, with casts of Uniones. 3. At Bowles's Farm, on the east of Cranley, is a bed of very compact sand-stone, apparently lower in the series than those above mentioned: and the roads hereabouts are repaired with grit from Newhouse, between Cranley and Ewhurst. Stone is also found nearly on the same line eastward, at Redford and Standling; and again on the south of Capel (on the road from Dorking, about a furlong north of the 30th mile-stone), is a prominent ridge, with a course of sand, in beds from 2 to 6 inches thick, in light-coloured clay.

The height last mentioned, near Capel, may probably be the continuation of a ridge which, on the Ordnance Map, begins about 3½ miles to the east of that place, passing from Stand-hill, through Norwood and Horse-hill; and which (being resumed on the east of the Mole), forms a range nearly parallel to the escarpment of the Lower green-sand,—by Lady-farm, about two miles south of Earlswood-common on the road from Reigate to Brighton, Outwood-common, Lostland, south of Gayhouse-farm, and thence, through Hook-stile, to the stream south of Comfort's-Place farm, and Moat farm. On the east of the place last mentioned, the ridges between the Lower green-

* See the eastern part of the Section, fig. 5.

sand and the Hastings sand, are not so well defined; but on the south of Boughton, a series of heights extends from Marden to the east of Staplehurst.

(78.) *Coast of Kent.* There is, strictly speaking, no section of the Weald clay and the upper part of the Hasting sands on the coast of Kent; the line of heights which, at some very remote period, may have been sea-cliffs washed by the English Channel, being now covered with vegetation, and separated from the sea by the wide tract of Romney Marshes. Having, myself, some years ago, observed indications of sand and stone, in the Weald valley near the coast where it is difficult to find good sections exposed, my friend the Rev. G. E. Smith was good enough, at my request, to examine that part of the country; and from his notes I learn that the greater part of the series there must consist of sand and sandy clay,—the blue fissile clay, which occurs in the upper part of it, not recurring, or not having been detected, farther down.

The first rise of the clay from beneath the green-sands, is represented in the view Plate VIII.; and the general section of the coast between Folkstone and Beachy Head, (Plate X. a. No. 6.) includes the strata on the west of Hythe. The shore beneath that town, which is sometimes laid bare, when the sea carries away the shingles, during the prevalence of easterly winds, consists of soft bluish clay, which has the characters of river mud, and differs much from the uniform slaty clay of the Wealds. But the latter has been cut through in sinking wells above the main street of Hythe, which, in some instances, have gone to the depth of 75 feet entirely in clay. In one of these wells, the succession of beds was thus;—beginning at a point about 60 feet beneath the bottom of the Lower green-sand.

Upper Part of the Weald-Clay at Hythe.

		Ft.	In.
1.	Soil	2	6
2.	Reddish tough clay*	6 to 7	0
3.	Greenish sandy clay, in thin bands, alternately of dark and lighter hues	5 to 6	0
4.	Blue, uniform, slaty clay, containing Cypris about a foot from the top	about 5	0
5.	A band, composed of argillaceous iron ore, abounding in *Paludina elongata*, and Cypris		?
		18	0
6.	Blue clay continued. Here a boring was made to a depth of about 20 feet: all in bluish clay	20	0
	Total	38	0

Blue clay with Cypris occurs also, according to the Rev. G. E. Smith, immediately below the green-sand, at Aldington Corner; but nothing like it, he informs me, in the succeeding parts of the section towards the south. A bed of limestone, with Paludinæ ("Sussex marble") occurs at Hurst†, beneath Court-at-Street, and seems to be continued in the clay which passes from that place round the base of Aldington Knoll; and a similar stone is found, in a corresponding situation in the cypriferous clay, at Daniell's Water on the south-west, Stanford Bridge, on the

* In descending from the sands at Linton, south of Boughton, and in many other places, the top of the Wealden is seen to consist of very red clay.

† The term *Hurst* is of such frequent occurrence in the names of places in Kent, Surrey, and Sussex, that the Ordnance Maps alone afford a List of about 120 such names. Having sent this List to the Rev. Joseph Hunter, late of Bath, that gentleman has favoured me with some obser-

west of Ashford, and near Bethersden, about 22 miles south of Stanford Bridge. A continuous range of slightly elevated ground, extending from Lovelace near Bethersden towards Shadoxhurst (in a direction parallel to that of the other ridges of this country, and to the range of the chalk escarpment), may also indicate the existence of some stratum of greater firmness than the clay.

Mr. Smith mentions two subordinate courses of sand, with sand-rock, sandy clay and loam, as occurring in the lower tract, or valley of the Weald, between Aldington Corner and the cliffs of sand and grit on the north of Rye. (1.) The first of these runs from near Bilsington, through Orleston; with which line a range in the interior seems, from the map, to be continuous, for about four miles more towards the north-west,—through Woodchurch Beacon and Redbrook Street. It seems to be parallel to the ridge above mentioned between Bethersden and Shadoxhurst; and sections of the strata are disclosed at Bilsington Priory; on the roads from Bilsington Cross to High-house; from Ruckinge to Ham Street, and from Ham Street to Orleston; and perhaps near Warehorn Leaton. (2.) The second course, which consists of red clay with sand and sand-rock, begins at Brookarm, on the verge of the marshes, and passes through Bench-hill. On the south of this last-mentioned range, sand and sandy clay appear to abound: concretional beds of hard

vations of so much interest, that, but for the immediate object of these pages, I should willingly have inserted them in full.

"The word," Mr. Hunter states, "does not occur in Lye's Saxon Dictionary; but I observe "that the modern Lexicographers speak of a Saxon word, hẏpſt, as synonymous with *sylva*; and "*hursta*, it seems, occurs in low Latin, for 'wood'. Wachter explains *Horst*, Germ., 'locus "'nemorosus et pascuus'; and refers it to ὄρος, mons. Kilian has *Horscht*, Teut. 'virgultum; "'sylva humiles tantùm frutices proferens.'

"In England, *Hurst* appears to signify a small wood; but, in Scotland, a barren height or "eminence, and sometimes a shallow in a river. I do not find the word," Mr. Hunter continues, "in any of the provincial glossaries; and yet I think it is not quite out of use, in its uncompounded "state, to denote a Wood, generally; but I much doubt whether any specific difference can be dis-"covered between the sense of this word and that of many other words, in a language which is "particularly rich in terms which designate woods, or woody places: *grove, thicket, copse,* "*brake*, &c.

"If *Drayton's* authority (*Polyolbion*, viii. 2.) were not thought sufficient to prove that in "England the word was formerly used to signify a Wood, the combinations in which it occurs in the "names of innumerable places, dispersed all over the southern part of the island (i. e. south of the "Tweed), would be sufficient to prove it. There is *Oak-hurst*, *Ake-hurst* (a varied form of *Oke-*"*hurst*); *Elm-hurst*, everywhere; *Ew-hurst*, *Hasel-hurst*, *Ash-hurst*, *Ashen-hurst*, *Maple-hurst*, "*Nut-hurst*, *Beam-hurst* (Staffordshire), *Brere-hurst*, *Box-hurst*; besides many *Hursts* without "any prefix,—of which *Hurst-Monceaux* is one; *Monceaux* being an addition made after the Con-"quest, from the name of some Norman Lord.

"So many instances in which the names of trees are united with this word, would, I think, of "themselves be sufficient to prove that it was really in use in England, in the sense of 'wood'; and "it may be added, that it lies deep in the language,—the woods so designated being older than "the towns which have risen near them, and those towns of Saxon foundation.

"Again, there are other instances in which the adjunct is congruous with this idea of *Hurst*; such "as *Hawk-hurst*, *Crow-hurst*, *Broad-hurst*, *Buck-hurst*, *Brocklehurst* (Brock-hole-hurst),—the wood "where the badger (brock) made his holes. So also *Brock-hurst*, *Park-hurst*, *Coney-hurst*, &c. &c.

"It must, however, be admitted, that there are many names of places, into the composition of "which the word *Hurst* enters, of which it is extremely difficult to trace the origin; and when "those for which we can account are taken out of the list, it is hard to form even a conjecture con-"cerning those which remain. In this respect, however, the compounds of *Hurst* are but in the "same predicament with the prefixes to *-ton*, *-ham*, *-field*, *-by*, and many of the local terminals; "and probably they are, in many instances, the names of early Saxon proprietors, detorted "from their original forms. Some, however, more skilful etymologist, or one better acquainted "with the language of our ancestors of the 6th and 7th centuries, when probably these names first "became fixed, might explain:—*Shadocks-hurst*, *Cog-hurst*, *Bub-hurst*, *Tile-hurst*, *Sissing-hurst*, "*Capen-hurst*, *Dicken-hurst*, &c. &c."

grit, with Paludinæ and Cypris, occurring in the sands about Stone and Knock-house; and still more conspicuously in the range of heights further south, which extends from Boons-hill to the cliffs below Playden, not far from Rye.

(79.) *Hastings Sands.*—Mr. Webster has described and given a drawing of the cliffs on the east of Hastings, in a preceding volume of these Transactions*; and a general section of the coast between the chalk downs of Kent and Sussex will be found in the annexed Plate, X. a. No. 6.† I shall not, therefore, here detail the stratification of this portion of the Wealden, especially as lists of the strata will be given hereafter, in describing the coast of the Isle of Wight and of Dorsetshire; but shall confine myself to an account of the cliffs, on the west of those represented in Mr. Webster's Sectional View,—which were uncovered to a great extent during the progress of the buildings and improvements recently carried on between Hastings and St. Leonard's‡.

(80.) *Shore on the West of Hastings.*—The anticlinal line of the ridge consisting of the Hastings-sands runs inland, from the shore towards a point about 60° west of north; beginning on the east of Hastings, about Lee Ness Point, and passing through Battle, and thence along a series of ridges, to its greatest height at Crowborough Beacon, on the south-west of Tonbridge Wells. The strike, on the west of Hastings, is not parallel to the anticlinal ridge, but oblique to it at an angle of about 44°, the strata running nearly from east to west, and dipping generally towards the south. The direction of the coast line for a short distance, at St. Leonard's, coincides with the strike, but from Hastings to the entrance of that place, makes an angle with it of about 10°,—the line of the shore running from about 14° north of east, towards the south of west; and on the west of St. Leonard's, the coast turns a little towards the north of west, and again makes a small angle with the strike. In going along the shore, therefore, from Hastings towards Bulverhithe, the strata first appear to be inclined

* Geological Transactions, 2nd Series, Vol. II. p. 31, &c. For additional information on the Wealden tracts in general, the reader is referred to Mr. Mantell's publications; Mr. Lyell's "Principles of Geology," (3rd edition), Vol. IV. chap. 21 and 23, pp. 165—191, 219, &c.; and to "A Sketch of the Geology of Hastings," 12mo, 1832, by the author of the present paper.

† This general section is on the same scale of relative height and horizontal distance, as all the others in Plate X. a.; but as a correct estimate of the elevation is, in this case, important to theory, the heights are given in true proportion, on the line immediately below, as has been done by Mr. Lyell, in one of his chapters on the structure of the Wealden.

‡ The Sections following in the text, from (80.) to (90.), formed the substance of a Notice read before the Geological Society, in November, 1833 (Proceedings, vol. ii. p. 1.); and are here introduced by the permission of the President and Council.

to the south of west; then to become horizontal; and beyond St. Leonard's, to rise a little from the sea,—the same beds recurring there in a reversed order. The Section, Plate X. b, fig. 2, which is on a much larger scale than Plate X. a, No. 5, represents the cliffs here referred to, and will illustrate the structure above described.

(81.) The top of the great stratum of white and nearly pure sand, which forms the cliff under the castle at Hastings, comes down to the shore at the White Rock, and disappears under the sea on the west of it. A stratum which has many of the same characters, and seems to be a continuation of that of Hastings, rises at the bottom of the cliff, about 350 paces west of the church at St. Leonard's; all the beds in the intermediate space being consequently higher in the series. There is still some obscurity as to their relations, from the effects of disturbance; and some points are concealed: but the following list gives an approach to the order of their succession, descending,—with an estimate of the relative thickness of the groups, and the places in which they are found.

Supposed Groups of Strata on the Shore between Hastings and Galley Hill.

No.		Estimated Thickness. *Feet.*	*Feet.*
I.	Sand, and sand-rock, in large proportion; with clay, in alternate courses		150
	a. Heights above and within the entrance of St. Leonard's, from Hastings ... 50		
	b. From the archway at entrance of St. Leonard's to Warriors' Gate..... 50		
	c. Space corresponding to the vacancy at Warriors' Gate (thickness estimated from the horizontal distance) 50		
II.	Sand-rock, clay, and Fuller's-earth.....about		75
	a. Heights between Warriors' Gate and the White Rock; nearly thus, in detail:		
	1. Slaty clay ..... 8 feet.	7. Dark sand-rock, with lignite.. 2	
	2. Sand and sand-rock..20	8. Alternations of sand-rock, sand, and sandy clay, about 25	
	3. Fuller's-earth 2	75?	
	4. Sand-rock 4		
	5. Fuller's-earth 2	9. Light blue clay, continued downwards into (III.).... ?	
	6. Sand-rock 12		
III.	Sand-rock, alternating with grit, slaty clay, and clay iron-ore, and including one or more layers of *Endogenites erosa*, with numerous other fossils.... between 50 and 60		
	a. Ledge under the White Rock.		
	b. Strata in the cliff behind the new Brewery on the east of the White Rock. *Endogenites erosa* in great numbers.		
	The connexion of *a.* and *b.* with the light blue clay, (II 9.) was not disclosed: but the whole group seems to be the same with III. *c.*		
	c. Ledge of rocks under the "Marina" at St. Leonard's.		
	d. Beds around St. Leonard's church, and in the cliff on the west of it.		
	At these places the grit and conglomerate include remains like those of Tilgate Forest.		

IV. White sand, and soft sand-rock, including thin flakes of light grey clay, and some portions of lignite..... upwards of 80

a. Cliff under the castle, Hastings.

b. Shore below, and on the east of the White Rock.

c. Bottom of the cliff, near the Sussex Hotel, west of St. Leonard's.

V. Brownish sandy clay, with much lignite, immediately beneath IV..... 35

a. Under the Castle-cliff, behind Pelham-place, Hastings.

VI. Yellowish and ferruginous sand, and sand-rock, including nodules of pyrites, and grains of reddish (pisolitic) oxide of iron..... ?

a. Shore, about low-water mark, beneath the town of Hastings.

b. Shore between St. Leonard's and the Martello Tower, No. 39.

VII. Variegated clay and sand, of various shades of red inclining to purple, and light greenish grey..... ?

a. Heights west of Bopeep.

b. Shore from Bulverhithe to Galley Hill.

c. Similar beds, with granular oxide of iron, are found on the east of Hastings, in the bay of the Lover's Seat, &c.

(82.) The following details respecting the strata just enumerated may be worth preserving, as the surface of the cliffs will probably soon be concealed.

I. *a.*—The highest members of this series are partially exposed on the north of the back street, near the eastern buildings of the Marina and the archway at the entrance of St. Leonard's; from whence down to the shore is a series of strata, which are horizontal on the line of the strike, but rise in reality towards the north, at an angle between 12° and 15°. The uppermost beds consist of soft grey sand-rock, with some intermixture of clay, and form a total thickness of about 66 feet above the road. The lower members are visible in the back street, and on the west of the houses are seen to rise towards the west. The horizontal portion occupies about 150 paces from west to east, and after that space, in consequence of a change in the direction of the shore towards Hastings, a rise towards the east begins to be apparent. The strata which connect this group with the beds of clay around the church hereafter mentioned (III. *d.*), have been carried away or are concealed.

I. *b.*—The group next below is partially seen on the shore between St. Leonard's and the White Rock. Between the archway and the vacancy in the range of heights, which is called *Warriors' Gate*, is a low cliff about 250 paces in length, and about 30 feet high, which has been cut away to admit of the erection of houses. It consists of sand-rock, alternating with clay or marl; the beds of which rise and disappear in succession, corresponding altogether to a total thickness of about 50 feet.

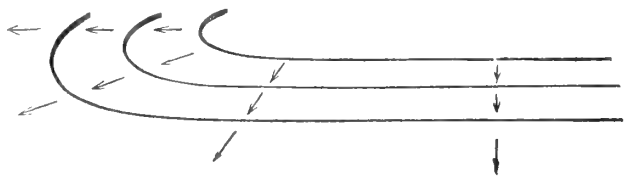
I. *c.*—The opening at *Warriors' Gate* occupies a horizontal space of about 300 paces, and within it, on the north, is a bank of sand-rock like the strata last described. On the east of this opening, a low range of grass-covered cliffs, from 40 to about 60 feet in height, extends without interruption to the beginning of the road over the projecting masses at the White Rock*; and two

* The storms during the high tides of 1833 and 1834, had so shattered the mass which bore the name of the White Rock, that very few of the interesting appearances represented and described by Mr. Webster now remain, the face of the rocks which afforded them having been either concealed or carried away. The destruction had been such in April 1834, that the town of Hastings, formerly concealed by the prominence of the shore, was then visible from the entrance of St. Leonard's.

remarkable beds of greenish Fuller's-earth, in general about two feet thick, but in some places much thicker, separated by about four feet of sand-rock, rise upon the road-side, and are continued steadily in the face of the cliff, nearly to the White Rock, being, near that place, more than 30 feet above the bluish clay (II. 9.) at the bottom. The base of the cliffs here is about 20 feet above a floor of rocks which is bare at low water, and consists of yellowish, firmly concreted sand, or sand-rock, abounding in granular (pisolitic) reddish oxide of iron*. This granulated rock forms, hereabouts, a ledge beneath high-water mark, dipping to the west of south, at an angle of about 11°, with a strike towards a point about 6° or 7° south of east.

II.—About 120 paces west of White Rock, where the road formerly began to rise over that prominence, the cliff behind the new houses, about 40 feet high, consists of a large proportion of sand and sand-rock, with alternations of clay; and in some places contains so much lignite, in the form of indistinct fragments of stems and portions of branches, as to have a dark brown or blackish hue. A bed of light bluish clay (II. 9.) forms the lowest part of this cliff, and seems to be continued downwards; it probably corresponds to the beginning of the series of beds of clay &c., (III. *c.*) near the church of St. Leonard's.

On the shore at low water, about 150 paces west of the place last mentioned, is a group of beds which are curved, so that their dip is divergent, those on the east dipping towards the south, at



an angle of about 10°; they consist of sand-rock, and may possibly be continuous with the sloping bed at the White Rock, shown in the section, and inferior to the bluish clay of II. 9. Other appearances indicate that this has been the scene of some derangement, so that the relations of the beds, above described, to those under the White Rock and on the west of it, are still doubtful: the whole series, however, is nearly conformable, and almost continuous with the rest of the strata towards St. Leonard's.

On the east and south of the nook, in which is the light bluish clay, II. 9. a bed of brownish sand-rock about 10 feet thick, immediately adjoins the road, dipping to the south of west, at a much more rapid inclination (about 18°) than that of the adjacent strata. This bed, nevertheless, may be a continuation of those which form the curve represented above; and its present position may have been the result either of subsidence, which has caused it to fall away from the apparently continuous mass of strata within it on the north, or of some more extensive derangement of the coast at this place.

III. *a.*—*White Rock Ledge.*—The great ledge visible upon the shore at low water, to the solidity of which the prominence of the White Rock (so long as it remained) was to be ascribed, rises beneath the sea, about 200 paces to the east of the rock, and seems to be continued for a considerable distance in that direction. A series of conformable strata of sand-rock, concretional grit, and slaty clay, here occupies the whole space between high- and low-water mark, for more than 100

* This stratum I did not see in these cliffs: but granular oxide of iron abounds in those on the east of Hastings, and seems to be very generally diffused in a lower part of the series. The grains which I have here called Pisolitic, seem to have existed originally in the form of iron pyrites;—of which substance globules of various sizes from that of pistol bullets downwards, are still found on the sand-rock at St. Leonard's. The origin of the ore of iron to which the name of Pisolitic has been applied, is ascribed by Haidinger to the decomposition of pyrites.—Translation of Mohs' Mineralogy, vol. ii. p. 412.

paces; with a strike to about 20° east of south, and dip to the west of south: and this remarkable group contains in some places pisolitic grains of reddish oxide of iron, disseminated in yellow sand-rock, like that which is found in the strata beneath.

III. *b.*—The beds in the upper part of the cliff behind the Brewery are a continuation of part of the group upon the shore (III. *a.*), and, like it, contain great numbers of the singular fossil which has been called *Endogenites erosa.* They are probably the same with those of III. *c.* which rise on the shore under the Marina at St. Leonard's, of which an extensive section was exposed in excavating the site of the church; and both groups are interesting, for their apparent identity with the Tilgate strata, which have furnished to Mr. Mantell an almost inexhaustible store of extraordinary fossil remains.

Beds of the Group (III. b.) in the Cliff on the North-east of the White Rock.

	Ft. In.	Ft. In.
1. Earthy brown sand-rock, about		2 0
2. A group, about 10 feet in average thickness, composed as below.		
a. Sand in thin courses, alternating with clay, which includes Cyclades. The sand passes into grit, and in some instances also abounds in *Cyclas media* in the state of pulverulent carbonate of lime. From the different hue of the sand and clay, the cross fracture is perceptibly striped in very thin layers; and in the darker beds the surfaces of the clay are often dotted with white specks, the sections of very small cylindrical cavities, now filled with very fine sand or clay, which seem to have passed through several of the adjacent folia, vertically or obliquely	2 0	
β. Thin courses of subcalcareous grit, alternating with bands of clay. The grit is in small concretional masses, often not more than half an inch in thickness, which thin off to an edge. On the surfaces adjoining the clay are very numerous Cyclades	4 0	
γ. Flat, nodular masses of argillaceous iron ore, containing Cypris. In the fallen debris are fragments, apparently from this place, which contain also clusters of *Paludina elongata* in great numbers	3 0	
δ. Soft argillaceous sand-rock, alternating with thin layers of darker clay, and including some portions of iron ore ..... about	1 6	
ε. Alternate layers of grey sandy clay, and yellowish ferruginous sand-rock, passing into grit, and including the remains of *Endogenites erosa.* This and the succeeding stratum very much resemble (*b.*) above	1 6	
ζ. Light greenish grey sand, passing into grit, and alternating with clay, as in (*b.*). This bed contains *Paludina fluviorum,* and *Cyclas media,* in great numbers	2 0	
		14 0
3. Yellowish sand-rock, with ferruginous stains, passing in some places into grit		3 0
4. Slaty clay, alternating with yellowish and brown sand, and including remains of leaves and stems, in the state of lignite, generally about $\frac{1}{20}$th of an inch in thickness. The lignite is divided into rhomboidal portions, separated by thin partitions of clay, which, when the coaly matter is removed by decomposition, have a deceptive resemblance to organic structure. This group passes insensibly into (5.)	?	

	Ft. In.	Ft. In.
5. Uniform sand, with alternations like those described above, (2. *b.* and 2. *e.*). Continued nearly to the bottom of the cliff, where the rock is a fine uniform white sand-rock, like that of the great cliff at Hastings. The distance from the bottom of 5. to the base of the cliff, is about		45 0
The total height of the cliff being..... about		65 0

The foregoing divisions are evidently arbitrary. In a general view, this section may be said to consist of rather more than 50 feet of thinly stratified sand and clay, with grit in concretions; including, at the upper part, a stratum of darker colour, about 12 feet thick, near the middle of which the remains of Endogenites are found.

(83.) The rock composed of alternating layers of sand, and darker sandy clay, No. 2. *a.* of the preceding list, constitutes a large proportion both of the Weald clay and the Hastings sands; and a similar alternation of sand and clay of different hues and consistency, extends upwards beyond the limits of the Wealden, into the Lower green-sand. When the masses of the rock are dry, the structure is less conspicuous, but it becomes beautifully apparent when they are moistened. The delicacy and distinctness of the folia which are then seen in the cross fracture of the beds, are very remarkable; the separate leaves being frequently as thin as paper, yet perfectly distinguishable, from their different alternating shades of greenish grey; and commonly continued with great regularity for considerable spaces; a structure clearly indicating very tranquil deposition, such as might be expected in a fluid suspending solid matter divided to extreme minuteness, yet subject to frequent changes at nearly equal intervals; which may well be conceived to have taken place in the waters of a lake or estuary, at different seasons, or during different conditions of the waters,—if it be going too far in theory to suppose the minuter laminæ to have been the produce of successive tides.

(84.) The continuity of the ledges of rock under the Marina at St. Leonard's, with those of the shore under the White Rock, is rendered more probable by the occurrence of the *Endogenites erosa* in both*. The principal ledge at the former place is very conspicuous on the shore at low water, and is one of the most remarkable geological features on the west of Hastings†. The following are the beds of which it is composed:

* I did not myself see this fossil at St. Leonard's; but Mr. Woodbine Parish, jun., informed me that the specimen represented in fig. 8, Plate XIX., was obtained at the foot of the cliff around the church.

† These prominent ledges are precisely analogous to those which occur in the Hastings sands on the south coast of the Isle of Wight, where several reefs of rocks run out almost directly into the sea, and have obtained separate names from the inhabitants. On the Sussex coast they are less conspicuous, from the more rapid dip towards the sea, and the obliquity of the strike to the line of the coast; but many more such ledges do exist, between the flat near Pevensey and Cliff-end, about midway between Hastings and Winchelsea;—see hereafter, (95.)

Beds of the Group (III. c.) composing the Ledge on the Shore beneath St. Leonard's.

1. Hard, subcalcareous, greenish grit, full of fossils; chiefly Cyclades, with Paludinæ, and some large Uniones	1 6 to 2	0

A thick and nearly continuous stratum, very like the stone of *Hollington* about $2\frac{1}{2}$ miles north-west from Hastings; its structure, however, like that of the White rock, is distinctly concretional. The top of the concretions, when exposed and washed by the sea, exhibits beautifully the minute stratification of the original sand; and the globular masses on the underside project into the sand (2.) below. The stone is traversed nearly at right angles by veins of calcareous spar, and includes portions of trees, converted into lignite. It is associated also with patches of a looser conglomerate, consisting chiefly of rounded grains of whitish, nearly opake, quartz, including the teeth, scales, and bones of fishes, and of a species of Trionyx ?. The strike of this stratum is about 10° south of east, and the dip towards the west of south, at an angle of about 11°.

2. Yellowish sand-rock, abounding in impressions of Cyclades, and also resembling part of *Hollington* group	4	0
3. A band of slaty argillaceous iron ore	0	3
4. Slaty clay, with numerous shells, chiefly Cyclades and Cypris	0	9
5. Continuous band of iron ore; like 3, above	0	2
Total about	8	0
6. Slaty clay with Cyclades and Cypris		

III. *d.*—The group last mentioned must be continuous with that in the height to the westward, although the connexion is at present concealed; for a line from the point where the grit rises from the shore, would reach the base of the vertical cliff near the church*,—where slaty clay, with grit and sandrock, occupy a thickness, according to the quarrymen, of more than 70 feet. The same strata then rise gradually westward, and disappear about 700 paces west of the church. Several quarries, concealed from below by a terrace-like projection, have been opened for the extraction of the grit near the top of these western heights: and a hard sparry conglomerate, immediately beneath the more uniform stone, has afforded many of the Tilgate fossils; a large collection of which, presented to the Geological Society by Mr. Woodbine Parish, includes specimens of bones and *teeth* of the Iguanodon, scales and other remains of Lepisosteus, and shells of the genera Paludina and Cyclas in profuse abundance. The cliff here may be about 90 feet in height, and its base about 25 feet above low-water mark.

List of Beds composing the Group (III. d.) at the Church, St. Leonard's.

	Ft.	In.	Ft.	In.
1. Soft sand-rock at the top of the hill (visible)			6	0
2. Greenish grey sand			2	0

* The dip, however, of the strata in this cliff, is not to the south, like that of the ledge under the Marina, but northwards; so that it is not impossible that there may be here some local derangement, though I saw no indications of it on the shore. I had, however, an opportunity, in an early stage of the improvements at St. Leonard's, of seeing what may have been a fault, in the rising ground on the west of the Assembly Rooms, which was then opened in preparing the foundations of some houses. The surface thus exposed was nearly at right angles to the coast, and consisted of sand-rock, over greenish clay or Fuller's earth, in regular strata, dipping north, about 20° east: while immediately without, and separated by a distinct vertical line or crack, was a mass of clay;—which, however, may have been brought into that situation by subsidence, as the place is close to the shore.

	Ft.	In.	Ft.	In.
3. Reddish, and purple sandy clay; thickness not ascertained.....				?
4. Blue and grey slaty clay, about.....			20	0
5. Greenish Fuller's-earth.....	2	0		
6. Dark shale	2	0		
7. Band of iron-stone	0	4	17	0
8. A band of clay iron-stone and slaty clay	2	0	to	
9. Slaty clay approaching to clay iron-stone.....	0	6	20	0
10. Firmer slaty clay including small flat nodules of iron-stone with numerous large Cyclades.....	10	0		
11. Hard grit, about.....			1	6
12. Soft sand-rock, in 3 or 4 courses			2	6
13. Firm sandy clay, with Cyclades; firmer and more sandy at bottom....			3	6
14. Yellow and reddish sand (or very soft sand-rock), in very thin alternating courses.....			1	0
15. Soft sand-rock, resembling the last but of lighter colour. This seems to go down to the base of the church. Visible, about.....			9	0
16. A bed of firm sand-rock (immediately on the east of the church), about			2	0
17. Thin beds of slaty clay; with interposed layers, or thin masses, nearly continuous, of clay iron-stone, including layers of Cyclades. Visible about			6	0
Total thickness (visible).....			70	0

The strata in the roadside on the east of the church dip towards the east of south, at an angle of about 10° to the horizon; but behind the church the dip is 3 in 40 (or about 4°), towards the *north.*

The following is an approximate list of the strata in the cliff on the west of the Sussex Hotel, between the bottom of the group last mentioned (III. *d.*), and the White sand-rock IV.; corresponding therefore to the strata on the east of the White Rock, beneath the group III. *a.*, which contains the Endogenites. The measures exceed the truth, but the proportions are probably correct.

	Ft.	In.
1. Brown sand-rock .....about	40	0
2. Sand-rock with clay, including Cyclades, about	6	0
3. Beds of darker hue, apparently consisting of clay and sand	10	0
4. Dark yellowish brown sand-rock	6	0
	70	0
5. Very white sand-rock, or slightly coherent sand, occupies about 30 feet at the bottom of the cliff, and is continued downwards. The femur of an Iguanodon was found in this stratum	30	0
Total about.....	100	0

IV.—In the space between the base of the cliff at the Brewery and the Castle-hill, all the beds have been carried away. But the great white sand bed IV. *a.* & *b.* is itself visible at high-water mark immediately below the middle point of the White Rock; and thence to the place where the road to Hollington is cut through this stratum. From the Castle-hill, where it is at least 80 feet thick, it is continued with perfect uniformity of character to the top of Fairlight Down*.

* The massive beds of scarcely concreted sand around Tonbridge Wells,—on the Race-ground, at Rusthall-common, and in the heights of Frant and Eridge-park, appear to be a continuation of

IV. *c.*—The white sand-rock above supposed to be a continuation of that on the Castle cliff, probably rises on the shore under St. Leonard's church, but is not visible in the cliff, till it reaches a spot on the east of the Sussex Hotel, where caves have been cut in the mass of almost uniform sand, not to be distinguished from that of Hastings. It would be very desirable to ascertain by experiment whether marine salt exists in this deposit.

V.—Immediately below the sand-rock (IV.), at the western extremity of the Castle rock, is a thickness of about 35 feet, of dark brownish, tough, sandy clay, including lignite in considerable quantity, some of the continuous pieces being several feet in length. This group goes down to the level of the road or street; and thence to low water mark, a space about 20 feet in thickness is concealed. But under the Parade on the east of Pelham-place, a floor of grey sand-rock, is exposed at low water, the strike of which seems to be nearly from east to west. It includes crusts and patches of brown oxide of iron; and is traversed by two sets of cracks, one running nearly north and south, the other from the north of east to south of west, which divide the surface into nearly rhomboidal portions, with angles of 72° and 108°.

VII.—*Cliffs on the West of St. Leonard's.*—The line of the coast at St. Leonard's coincides with the strike for about 200 paces west of the arch at the entrance to that place; and the strata at the water level appear to be horizontal; but about 400 paces west of the Sussex Hotel, the heights turn inland towards the north of west; so that the strata in the retiring portion of the cliff are lower in the series than those upon the shore. They agree with those which are visible at low water beneath the town of Hastings, and with the lower strata in the cliffs around the shallow bay, or cove, at the Lover's Seat.

VII. *a.*—The cliff west of the Church is continued for some distance at an uniform height of about 100 feet. It becomes lower in approaching Bopeep; and at a point where it turns inland, between 200 and 300 paces east of the Martello Tower No. 39, is a floor of sand-rock, at low-water mark, full of grains of oxide of iron, like that of the coast to the eastward; the strike being towards the east about 25° south; and the dip east of north, at an angle of about 11°. The upper part of the cliff at this place, which is about 40 feet high, is composed of brown sand-rock, in beds from 2 inches to 6 in thickness. A grass-covered height, of less elevation, occurs immediately on the west of Bopeep, and the rock exposed there to a thickness of about 10 feet, consists of reddish sandy marl (VII. *a.*), not distinguishable from the Red marl of Devonshire. A low flat hill about 300 paces west of the Tower No. 40, consists for about 20 feet at the top, of sand alternating with clay, in beds dipping very gently to east of north.

VII. *b.*—At the east end of the cliff at Bulverhithe, on which stands the Tower No. 43, the beds dip regularly about east 30° north, at an angle of about 1°. Thence, along the shore, to the Tower upon Galley-hill (No. 44.), strata of reddish sandy clay or marl, variegated with light tea-green, are very well disclosed, declining, towards the east, at an angle between 2° and 3°: and above these coloured marls, is brownish sand-rock, about 50 feet thick.

this stratum of Hastings. On the north of those great beds, and above them, is a group composed of thin, alternate beds of sand-rock and slaty clay, in many respects resembling that of the Brewery near the White Rock. These upper beds are quarried at Huntley's Farm, about a mile west of the northern entrance of Tonbridge Wells; where they abound in Cyclades, Paludinæ, and *Cypris Valdensis* (*C. Faba* of Min. Conchology), and include the remains of several plants, among which are *Sphænopteris Mantellii*, and a new species of fern, represented in the wood-cut at p. 181. The relations of the strata at this place, and in the tract on the north of it, towards the valley of the Weald, are well deserving of attentive examination: I am indebted to the Rev. Mr. Pope of Tonbridge Wells, for having pointed them out to me, and for a collection of specimens obtained there by himself.

On the west of Galley-hill, the strata in the banks, which scarcely can be called cliffs, are inclined slightly to the west of south; and the flat shore, near Cowden Point, consists of beds of clay and sandy clay, varying in colour from dark to bright blue, declining very gently towards the south-west, and extending outwards to some distance under the sea, with a strike towards a point about 16° south of east. Under the Martello Tower, No. 51, about four miles west from Galley-hill, is sand-rock, with ferruginous seams, and thin alternating beds of clay, slightly inclined to the west; from their situation not improbably one of the groups subordinate to the Weald-clay mentioned by Mr. Martin.

(85.) *Endogenites erosa.*—In cutting down the cliff on the east of the White Rock, immediately within the site of the new Brewery, large surfaces of the several strata were successively laid bare; and I was so fortunate as to visit the place when one of them was exposed, which contained a great number of the singular fossil bodies to which the name *Endogenites erosa* has been given, and to see some of them in their original position before they were disturbed. The workmen assured me that the fossils had been still more numerous in a portion of the same strata cut away not long before.

The place in the series, of the strata which include these fossils, has been already mentioned (p. 164–8.). I observed but one line in the face of the cliff which seemed to afford them, about 6 feet from the top of the group III. *b.* (81.) and (82.), which was about 10 feet in total thickness. The workmen told me, however, that some were afterwards found at a short distance below, where the strata were still nearly the same. I did not find any specimens of the fossil upon the shore; but fragments are frequently washed up by the sea in the neighbourhood of this place; and I saw a very large specimen in the face of the bank, on the side of the road over Cuckoo Hill, which joins that from Hollington to Hastings. Mr. Woodbine Parish obtained one, (Plate XIX. fig. 8.), which was dug out in his presence near the Church at St. Leonard's. Their occurrence at Tilgate Forest, where they were discovered by Mr. Mantell, has been mentioned in the Geological Transactions and in his own publications*; and Mr. Martin mentions the Endogenites, as having been found near Mulsey, in Western Sussex, in the first course of sand with reddish clay, subordinate to the Weald-clay, and above the Sussex marble†. There can be little doubt that when the corresponding beds in other parts of the Wealden district have been examined, they will be more extensively discovered.

The rapid change of character in the beds of this formation appears from the fact, that the great concretions of grit, several feet in length, and 2 or 3 feet in thickness, which are found upon the shore to the westward, do not occur in this cliff, though not more than 200 paces distant; their place being apparently supplied, in the strata above those which include the Endogenites, by nodular masses of hardened sand-rock. The bed III. *b.* 2. *e.* (p. 167.) which includes these fossils, passes both above and below into the adjacent strata, but has in general a darker hue. The fossils were closely enveloped in a mass of slightly coherent sandy clay; and I was enabled, with care, to preserve some specimens, (one of which is represented in Plate XIX. fig. 4. *a.* and *b.*) with part of the surrounding rock still adhering, as a proof that the coating of coal by which the nucleus was invested had never been of greater thickness, and that the whole of it was retained.

(85.) All the specimens of this singular fossil which I saw, lay with their

* Geol. Trans., 2nd Series, vol. i., p. 423;—and Mantell's Fossils of Tilgate, p. 54.
† "Memoir" &c. p. 41, note ‡.

longer diameter and their flatter surfaces in the horizontal position. Their appearance when first uncovered by the removal of the rock above, was that of elongated and flattened elliptical bodies, tapering at both extremities; as represented in fig. 1. of the subjoined wood-cut. They consist of two distinct portions; a stony nucleus, of a dark brownish grey colour, with a very slight tinge of purple; and a crust or case, in the state of lignite, which has externally a nearly uniform surface, and varies in thickness, in different specimens, and in different parts of the same specimen, from about $\frac{1}{10}$ to $\frac{1}{2}$ an inch. This crust becomes thicker near the extremities of the nucleus, and, in many instances, extends considerably beyond it, in a sort of appendage at both ends; but in other specimens of smaller size these appendages do not appear to have existed. The annexed wood-cut explains the structure of one of the largest specimens, and shows the relative proportion of the parts; and the figures in Plate XIX. show some of the principal varieties of form which the fossil has hitherto presented.

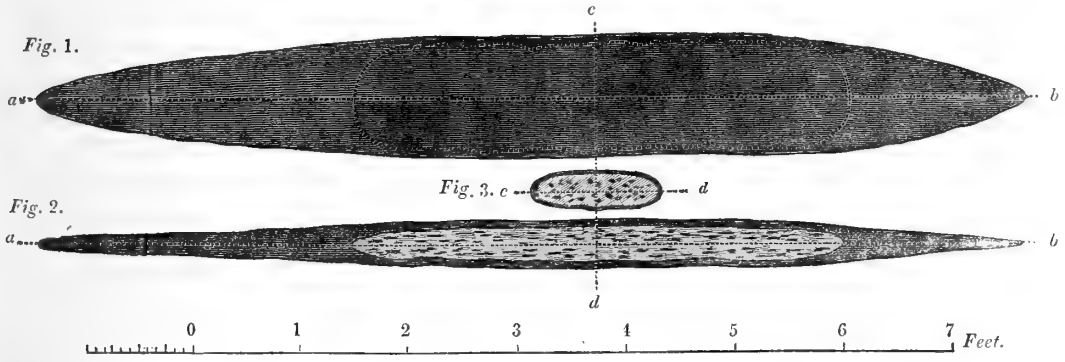


Fig. 1 of the wood-cut on this page represents the external appearance of the entire fossil, as seen from above; the situation of the nucleus being indicated by an obscure dotted line. Fig. 2 is a longitudinal and vertical section, on the axis or line *a*, *b*; and fig. 3, a transverse vertical section, on the line *c*, *d*; showing the proportion of the coating to the nucleus.

The figures in Plate XIX., which are on a scale of one sixth, in diameter, of the natural dimensions, are intended to represent some of the forms of the complete fossil, and of the nucleus when divested of its coating of coal. They are, however, from necessity so much reduced, as to convey but a very imperfect impression of the bulky objects which they represent.

Fig. 1 represents the greater part of a very large nucleus, of which only one of the extremities seems to be wanting. The remaining extremity is of irregular shape, as if it had been broken; and the specimen is much compressed in the middle. Fig. 2 is a nucleus apparently complete, tapering towards one extremity, nearly as may be supposed to have been the case in the part which is wanting in Fig. 1. Fig. 3, *a* and *b*, are horizontal and side views of a much smaller specimen, still retaining its coaly covering, with part of the smooth surface, hereafter mentioned. Fig. 4 is a larger specimen, with some of the sandy clay in which it was imbedded still adhering, the laminæ of which are curved as if they had adapted themselves to its form. The specimen

retains the greater part of its covering of coal, which has a smooth outer surface, of a light brown or drab colour: and at the lower part, a portion of the coal has been drawn away from the nucleus, apparently by the contraction of the investing matter to which it strongly adheres. One end of the specimen, where a portion has been accidentally broken off at *b*, shows the proportionate thickness of the coating to the nucleus within. Fig. 5 is a smaller nucleus, nearly complete, very short in proportion to its width. Figs. 6 and 7 are sections of specimens broken across, and exhibiting the flat surface of the fracture in the nucleus, with the proportion of the coaly covering, and the porous structure of the nucleus. Fig. 8 is the nucleus of a large specimen found by Mr. Woodbine Parish, in the strata near St. Leonard's Church. It is remarkable for the compressed appearance of one extremity, and seems to have been originally longer in that direction. It still retains a portion of the investing coal, and of the smooth outer surface of that coating, but the greater part has been removed or disturbed. Fig. 9 is taken from a specimen from Tilgate Forest, presented to the British Museum by Mr. Mantell, which is remarkable for its length, its nearly cylindrical figure, and the acute tapering of the extremity. The superficial furrows also, in this specimen, are deeper and much larger than in the greater number of the nuclei found near Hastings*; but in this respect it is approached by Figs. 1 and 2. Fig. 10 represents rather more than one half of a complete nucleus, of the natural size: the upper surface of *a*, of which fig. *b* is a separate representation, showing the appearance of a fracture on the line of the longer axis.

(86.) The size of the different specimens varies considerably. The largest that I saw in its place, and from which the foregoing wood-cut was taken, must have been in the whole full nine feet long; but there were portions of other nuclei of greater size, among the fallen specimens previously dug out. The lignite at one extremity was three feet in length; the nucleus $4\frac{1}{2}$ feet; and the workmen assured me that the coal at the other end extended to about 18 inches. The width in the middle was 12 inches, and the greatest thickness 4 inches. Another specimen, which had been for some time exposed to decomposition, was about $7\frac{1}{2}$ feet long; the nucleus about $5\frac{1}{2}$ feet, with about 12 inches of lignite remaining at each extremity; and from these dimensions there seem to have been gradations down to a few inches in length. The nucleus of the smallest specimen that I obtained, which is represented, of its natural size, in Plate XIX., fig. 10, is not more than 3 inches long, and about 2 inches wide; yet the external figure is complete, and the internal tubes are not smaller than most of those in the largest masses.

(87.) The original form of this vegetable was probably cylindrical; and that shape is still retained in a large specimen of a nucleus from Tilgate Forest, now in the British Museum; Plate XIX., fig. 9: but in the majority of the specimens the figure has evidently been compressed, and the section is now an oval variously modified; figs. 6, 7, 10. In those represented in

* Since this sheet has been at the press, I find, on examining several other specimens in Mr. Mantell's museum, that the uncompressed figure and greater size of the external tube-like furrows, are general characters of this fossil at Tilgate Forest.

figs. 2 and 9, the extremity is more acute than in the greater number of the specimens. In a few instances (as in fig. 8, and less obviously in figs. 2, and 1,) the nucleus seems to have been suddenly reduced in thickness near the broader end; but no specimen of this form was observed *in situ*. None of the specimens exhibited the tapering figure, somewhat like that of a ninepin, represented in the engraving in the Geological Transactions*; but many of the broken and worn fragments washed up on the shore near the White Rock had acquired some approach to that form. There was not, in any of the specimens, the slightest indication of lateral branches from the main body; but they all lay as if they had been distributed without connexion in the stratum in which they were found.

(88.) The coaly covering did not, in any instance, show traces of organic structure; it burned with a slight flame when thrown upon hot coals, and in the flame of a candle became white, and was reduced in bulk without losing its form. In some of the fresh specimens it was coated with a thin crust, of a light brownish or drab colour, with a very slight glistening lustre; apparently consisting of compressed clay. This is represented especially in figs. 4, *a* and *b*, and partially shown in figs. 3 and 8.

(89.) The internal structure of this fossil has been partially described and represented in the Geological Transactions†, by the Secretaries and a Committee of the Members. I am enabled to add some further particulars to what is there stated, through the kindness of my friends Mr. Brown and Mr. Stokes: the former having lent me the specimen represented in Plate XX., fig. 3., and given directions for making the slices, figs. 1. and 2.; to which Mr. Stokes was so good as to add a very thin slice, represented in figs. 4. and 4. *a*. The vermicular cavities or tubes, of which a longitudinal section is represented in fig. 1., and a transverse section in fig. 2. and 4., are all coated within with transparent quartz crystals, the summits of which are discernible with a lens; and in some cases the cavity of these tubes was partially occupied by exceedingly minute crystals of quartz, either detached in the state of sand, or intermixed with a flocculent coaly matter. The transverse sections of these tubular cavities exhibit a similar change of form, from circular to elliptic, to that shown by the entire plant. In the greater number of cases no trace of truly organic conformation could be detected with the microscope in these sections; but in two specimens a distinct indication of the original vegetable structure was to be seen. These are represented in Plate XX., figs. 3. and 4. The former figure, drawn from the extremity of a solid and opake

* Second Series, vol. i. Plate 48.

† Second Series, vol. i. Plates 46 and 47: and Mantell, Tilgate Fossils, Plates 2 and 3.

mass, a little decomposed, shows, within a cavity, a somewhat circular band, exhibiting organic structure, which is probably tubular*; and the same kind of structure is indicated in the other figures, 4. and 4. *a*, which are taken from a transparent slice belonging to Mr. Stokes; the latter being a more highly magnified portion of fig. 4.

(90.) *Fossils of the Wealden.*—The catalogue of the organic remains of Sussex, published by Mr. Mantell in the last volume of these Transactions, and which he has stated to have been intended to accompany these pages†, renders it unnecessary to insert here the fossils of that portion of the Wealden. The following list, therefore, will contain such species only as have been found in the tracts described in the preceding pages of this paper, or as do not occur in Mr. Mantell's catalogue: and I have been enabled to add several species to those of my own collection, through the kindness of Lord Greenock, Mr. Hills, Mr. Martin, and especially of Mr. Mantell.

List of Fossils of the Wealden, in Kent, Surrey, Hants, and Western Sussex‡.

Bulla Mantelliana. Pl. XXII. f. 3. With *Unio antiquus*, within a cavity in the grit of Tilgate Forest: M.

Corbula alata. Pl. XXI. f. 5. Pounceford near Burwash, Sussex: M.

Cyclas angulata. Pl. XXI. f. 12. Weald clay: M.

C—— *major*. Pl. XXI. f. 13. Weald clay, in nodules of clay iron ore, with *Cypris Valdensis* and *Paludina elongata*, Hythe (Kent): F. With Cypris, fish-bones, and pyrites, in iron ore; upper part of the Weald clay, near Pulborough: Martin. Henhurst, near Ockley, Surrey; in Weald clay. With *Paludina fluviorum* in thin bands of very hard ferruginous calcareous grit, passing into ferruginous sand; near the top of the Weald clay on the west of Leith-hill, Surrey: F.

Cyclas media. (*Cyrena media*, Ann. of Phil. Vol. VIII. p. 376. *Cyclas media*, Min. Con. Tab. 525. f. 2.) Pl. XXI. f. 10. So generally diffused throughout the Wealden strata that the specification of localities is hardly required. The following are some of the circumstances under which this shell has been found. In coarse grit near the top of the Weald clay, at Atherley, south of Tanhurst, Surrey. In very compact uniform grit, with thin carbonaceous vegetable impressions,—shell calcareous: also in very fine-grained micaceous sand-rock, with

* In this figure, from the greater difficulty of representing the opake object, the partitions between the dark spots which denote the cavities of the tubes, are much too wide: the real proportion of the cavity to the partition is more correctly expressed in fig. 4. *a*.

† "A Tabular Arrangement of the Organic Remains of the County of Sussex." Geological Transactions, 2d Series, vol. iii. p. 215.

‡ In this list the letter M. denotes that the specimen is in Mr. Mantell's collection; F. in that of the author.

Cypris; impressions only, without traces of the shell: Hollington, near Hastings. In nodules of clay iron ore: Cliffs west of St. Leonard's. In shale, called "Shab," alternating with beds of limestone called "Greys," (a stone almost entirely composed of thin shells): Limestone pits north-west of Battle: F. With *Paludina fluviorum*, in bluish compact and sparry limestone, ("Sussex marble"); Daniel's Water, Kent. In sand-rock near Tunbridge Wells: M. At the top of the Weald clay, mixed with bivalves of the Lower green-sand; Stopham brick-yard near Pulborough: Martin.

Cyclas media. (Young.) Plate XXI. f. 9. Hastings sand, Hollington, in hard grit; shell converted into carbonate of lime: F. Etchingham near Robertsbridge, Sussex: M.

C—— ——. (A gibbose variety.) Plate XXI. f. 11. Penhurst pits, in a bed of limestone, about 3 inches thick called "Top-greys": F.

C——. A wider species than *media.* Hastings sand, Hollington: F.

C—— *membranacea.* (*Cyrena membranacea*, Ann. of Phil. 1824. VIII. p. 376.) Cliff west of St. Leonard's, in sandy shale, with Cypris: F. Weald clay, Shipley, near East Grinstead, Sussex, with a spiral univalve (Potamides?): M. Limestone pits near Battle: F. Penhurst, Ashburnham, and Pounceford: M.

C—— subquadrata. Plate XXI. f. 8. Hastings sand, East Cliff, Hastings, in soft, fine, sandy clay, not effervescent: also cliff west of St. Leonard's: F.

C——. One or two other species, probably new, occur in the Weald clay, at Atherley, Surrey: F.

Cypris granulosa. Pl. XXI. f. 4. In ferruginous sand, Tilgate Forest: M.

C—— tuberculata. Pl. XXI. f. 2. Frequently black. With *Cypris Valdensis* and *Paludina elongata*, in nodules of clay iron ore, near the top of the Weald clay: found by Lord Greenock, at Hythe

C—— Valdensis. Pl. XXI. f. 1. (*C. Faba*, Ann. of Phil. 1824, VIII. p. 376.; Min. Con. Tab. 485.) This fossil occurs in such numbers in every part of the Wealden group, that it may be considered as characteristic of the formation; and being found in all the places where these strata have been hitherto observed, the specification of localities would be superfluous. Its profuse abundance may perhaps be accounted for by the fact, that the animal which inhabits the valves or crusts, sheds them periodically*. The Cypris to which the specific name of "Faba," was given by M. Desmarest†, occurs in strata probably superior to the chalk; and though the characters of the valves nearly approach to those of the Wealden Cypris, M. Deshayes is of opinion that it probably constitutes another species‡. On these grounds, I have thought it expedient to adopt a new specific name for the fossil represented in Pl. XXI. f. 1.; and that of *Valdensis* (of, or belonging to the *Wealden*) is intended to indicate both its geological or stratigraphical position, and the local situation of the tract in which it has hitherto been found in the

* Lyell "Principles," &c., 3rd edition, vol. iv. p. 98.

† Brongniart and Desmarest, "Crustacées Fossiles," p. 141, Pl. XI., fig. 8.

‡ "Coquilles Characteristiques," p. 255, Pl. 10. figs. 4. and 5.

greatest abundance. A description of the several species of this genus represented in the annexed plates will be found hereafter, in the Appendix.

Melanopsis ? attenuata. Pl. XXII. f. 5. (*Melania attenuata*, Ann. of Phil. 1824, VIII. p. 376.) In the Hastings sands, Hollington: F. Pounceford: M.

M——— *? tricarinata.* Pl. XXII. f. 4. (*Melania tricarinata*, Ann. of Phil. ibid.) Pounceford near Burwash, Sussex: M.

Mytilus Lyellii. Pl. XXI. f. 18. Beds below, or at the bottom of the Hastings sands, near Battle: F. In slaty clay, near Pounceford: Messrs. Lyell and Mantell.

Neritina Fittonii. (Mantell; South-East of England, p. 248.) Pl. XXII. f. 7. Casts in the grit of Tilgate Forest: M.

Ostrea ? (a thin-shelled species). Sand-rock of the Hastings sands, west of St. Leonard's: F.

Paludina carinifera. (Min. Con.) Hastings-sands, west of St. Leonard's; below the White Rock, Hastings; and at Hollington: F. In Septaria, at Resting-oak Hill, near Lewes: M.

P——— *elongata.* (Min. Con.) This fossil is very generally diffused in the Wealden strata. It occurs in nodules of clay iron ore, near the top of the Weald clay, at Hythe: F. In hard blue grit, with *Cypris Valdensis* and *C. granulosa ?* In the grit of Tilgate Forest: M. Near Ockley, in Surrey: F.

P——— *fluviorum.* (*P. vivipara*, Min. Con.) One of the most abundant univalves of the Wealden. On compact calcareous beds in the Weald clay; Bethersden and Daniel's Water, Kent. At Henhurst, Surrey; in ferruginous sandstone. In concretions of grit in the Weald clay, very large. At Forest-green, and near Ewhurst, Surrey; near Ockley, Surrey, with *Cypris Valdensis*, in beds of "Forest marble." South of Den-park, Sussex: F.

P——— Sussexiensis. Pl. XXII. f. 6. Resting-oak Hill, near Lewes, Sussex: M.

P——— two or more other species, probably new, occur at Tilgate: Mantell.

Potamides ? With *Cyclas media*, in shale, alternating with limestone; pits north-west of Battle: F. In Weald-clay, East Grinstead: M.

Psammobia ? Tellinoides. Pl. XXI. f. 6. With Cyclas in limestone; Pounceford near Burwash, Sussex: M.

Tornatella Popii. Pl. XXII. f. 8. Lenthington (pronounced Langton) Green, near Tonbridge Wells, in dark brown ferruginous sand-rock, with Unio, Cypris, and Cyclas: Rev. Mr. Pope; and M.

Unio aduncus. Min. Con. Bolney, near Pulborough: Martin. Near Cuckfield, Sussex: M.

U— antiquus. Min. Con. Weald clay, near Pulborough: Martin. Tilgate Forest, very frequent: M.

U— compressus. Min. Con. Weald clay, near Pulborough: Martin. Tilgate Forest: M.

U— cordiformis. Min. Con. Tilgate: M.

U— subtruncatus. Pl. XXI. f. 15. With *Cypris Valdensis*, *Cyclas media*, and *Tor-*

natella Popii? in dark brown ferruginous stone, Lenthington-green, near Tonbridge Wells. Also at Tilgate Forest: M.

Unio Gualterii. Pl. XXI. f. 16. Discovered by Mr. Walter Mantell in the dark brown ferruginous sandstone of Lenthington-green, near Tonbridge Wells: M.

U— Mantellii. Pl. XXI. f. 14. In calcareous grit, passing into ferruginous sand, near the top of the Weald clay; Atherley and Henhurst, Surrey: F. Tilgate: M.

U— Martinii. Pl. XXI. f. 17. Upper part of the Weald clay, near Henhurst, Surrey: Martin, and F.

U— *porrectus**. Min. Con. Weald clay, near Henhurst and Atherley, Surrey: F. Large specimens, with *Paludina fluviorum* and *Cyclas media*, occur in the cliffs west of St. Leonard's, in firm bluish grit: F. In sandstone, Tilgate Forest: M.

Reptiles. The reptiles of the Weald clay and Hastings sands in Sussex, nearly all of which have been discovered by Mr. Mantell, have been so fully treated of in his various publications, that I shall refer to those works for an account of them, and here only enumerate their names, with some of the chief places of their occurrence. The remains, however, of oviparous quadrupeds seem to be dispersed throughout the whole of this formation, though hitherto found principally in the Weald clay and the upper part of the sands beneath it: it is from this latter situation, in the grit and sand-rock of Tilgate Forest, that the greater number of Mr. Mantell's specimens were obtained.

Trionyx Bakewelli. (Mantell, S.E. of England, p. 255.) Tilgate Forest.

Emys, (species unknown.) Same place.

Chelonia. Ditto.

Saurians,—of at least six genera.

Crocodile. Remains of two, if not of four, species. (Ibid. p. 265.)

The teeth, scales, and some of the bones, are mentioned by Mr. Mantell, as occurring at Tilgate. A vertebra, which was considered by the Baron Cuvier, as belonging to this genus, was found in the strata of shale and limestone at the bottom of the Hastings sands, near Brightling, Sussex: F.

Phytosaurus cylindricodon. The teeth: Tilgate Forest. (Mantell, S.E. of England, p. 292.)

Plesiosaurus. Vertebræ, teeth, and other remains: Tilgate. (Ibid. p. 281.)

Megalosaurus Bucklandii. The teeth, (supposed) ribs, and vertebræ. Tilgate Forest. (Ibid. p. 260.)

Hylæosaurus. (First described by Mr. Mantell, in a paper read before the Geological Society (Proceedings, &c. Vol. I. p. 410.), and since published in his Geology of the S. E. of England; p. 289, &c. Plate V.) The remains were found in Tilgate Forest.

Iguanodon. (Mantell, Philos. Trans. 1825, p. 179.) The remains of this mon-

* Several indistinct specimens of this genus, including probably some new species besides those above mentioned, have been found at Henfield and Atherley, in Surrey, by the Author; and near Pulborough, by Mr. Martin.

strous reptile have hitherto been found chiefly in the upper part of the Hastings sands at Tilgate Forest: but very large bones, belonging, as it now appears, to the same animal, have been obtained much higher up in the Wealden series, at Loxwood, and Headfold wood, in Western Sussex*: and very recently, even beyond the limits of the Wealden group, among the lower strata of the Green-sand, near Maidstone, (as already intimated, p. 132; note †): they occur also as far down as in the Great Sand-bed of the cliffs on the coast near Hastings, where that stratum reappears on the shore west of St. Leonard's. I am requested by Mr. Mantell to state, that the mass of remains from Maidstone confirms the appropriation to this reptile, which he had previously made, of other bones of great size found detached, and in different places; and that, among other new points in the osteology of this extraordinary creature, the Maidstone specimen has enabled him to ascertain that certain phalangeal bones which approach to the mammalian character,—with flattened claw-like extremities, resembling those of land-tortoises,—belong to the *hind* feet of the Iguanodon; while the fore feet of the creature appear to have been long and slender, like those of the recent Iguana.

In addition to the Saurian remains which can be referred to distinct genera, there are also in Mr. Mantell's collection, detached bones, probably belonging to new or nondescript reptiles.

Birds. Fragments of some long bones found at Tilgate, and at first supposed to have belonged to Pterodactyles, appear to be really those of a bird, probably a species of Ardea. (Mantell, S. E. of England, p. 283.)

Fishes. The fishes of the Wealden, especially of the two upper members, have hitherto been imperfectly collected; and it still remains to be determined to what species of this tribe many of the remains which frequently occur in the Weald clay are to be referred. All the specimens from this formation in the collections of the Geological Society, of Mr. Mantell, and Mr. Martin, have been recently examined by Mr. Agassiz, with a view to his work on Fossil Ichthyology, now in progress; and the following are some of the genera to which he has referred them.

Pycnodus microdon. Teeth. (Represented in Mantell's Tilgate: Pl. XVIII. f. 26, and 27.)

Hybodus grossicomis. Teeth. (Ibid. Pl. V. f. 14, and XV. f. 2.)

———. Two other species, not yet figured.

———. The dorsal defences referred by Mantell to a Silurus, (Ibid. Pl. X. f. 4, and f. 6.), Mr. Agassiz considers as belonging to an Hybodus.

Lepisosteus. (*Lepidotus*, Agassiz.) The remains of one or more species of this genus have long been known, as diffused throughout the Wealden; in every part of which detached scales and fragments of the scale-covered surface are very commonly found. The Teeth are represented in Mantell's Tilgate fossils, Pl. X. f. 2.; the scales, in Pl. X. figs. 3, 4, 15, and 16; and from an examination

* Murchison: Geol. Trans. 2nd Series, vol. ii. pp. 104, 105.

of these, and of some very fine specimens of the head and fore part of the fish, belonging to Mr. Martin, Mr. Agassiz has been led to divide the genus into two species, distinguished by the forms of the teeth.

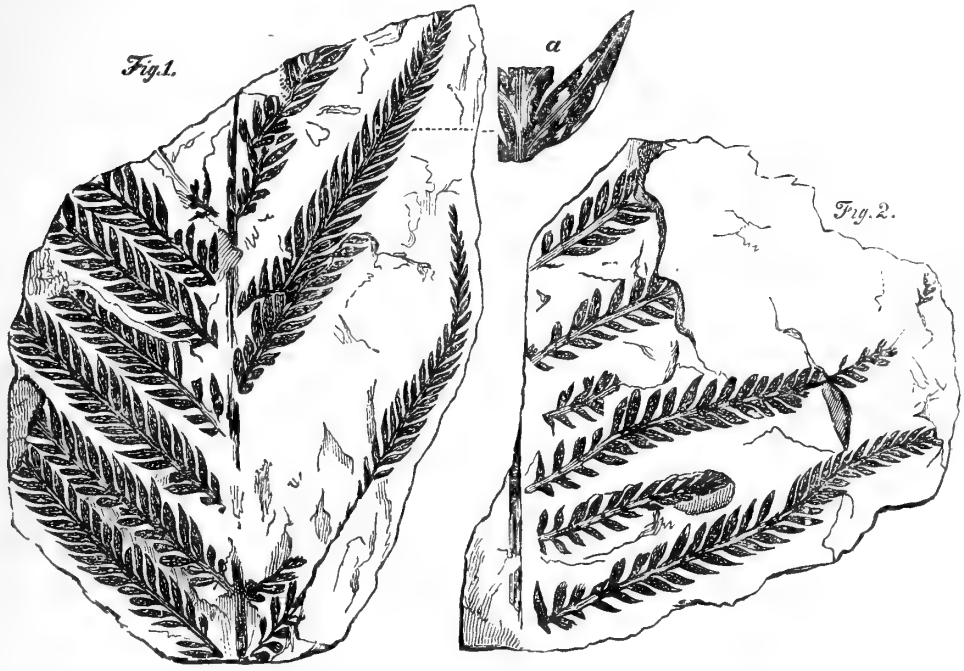
Coprolite,—(or, more correctly, masses of phosphate of lime approaching to the form, and possessing many of the chemical characters of Coprolite,) has been found by Mr. Martin in cavities on the surface of the Weald-clay, at Stopham brick-yard, near Pulborough, but so mixed with fossils of the Lower greensand that the whole may probably have belonged to that formation. The recent discovery of the Iguanodon, near Maidstone, forms an additional link of connexion between those two formations; and coincides with other evidence which indicates the probable continuity of their deposition.

REMAINS OF PLANTS.

A *Cone* of an unknown species, (Pl. XXII. f. 10.), remarkable for the double prominence, or ridge, in most of the scales; (see Appendix No. 1.): in a mass of hard, greenish grit. From a quarry on the estate of Henry Shirley, Esq., at Pippingford in Ashdown Forest, very near the highest point of the ridge of the Hastings sands.

Endogenites erosa. (Plates XIX. and XX.) Described in the preceding sections (85.) to (89.). Tilgate Forest: M. Coast west of Hastings: F. In the first course of sand in the Weald-clay, near Mulsey's Farm, about $2\frac{1}{2}$ miles north-east of Pulborough, on the main road to London: Martin.

Sphenopteris gracilis: represented in the subjoined wood-cut. See the descriptive note in the Appendix A, p. 349. From beds of sandrock and slaty clay, in the quarries at Huntley's Farm near Tunbridge Wells, above the great bed of White sandrock: Rev. W. L. Pope.



The Isle of Wight.

(91.) The general relations of the strata on the southern coast of the Isle of Wight, have been described by Mr. Webster* with so much ability, that little was left to succeeding observers but the task of filling up details, and of supplying some facts respecting the lower members of the series, which did not fall within the immediate scope of his inquiries. Having already published a general account of these lower strata in another place†, I shall here give some farther observations on what is commonly called "the back," or south side, of the island.

(92.) As the chalk passes entirely across the Isle of Wight, nearly from west to east, in a narrow ridge composed of vertical strata, and again invests a portion of the southern promontory of the island, with a cap of almost horizontal beds, at present detached from the central ridge and extending nearly to the sea,—the result is, that two very distinct sections of the vertical chalk and inclined strata beneath it are disclosed upon the shore, at the extremities of the central range; and again, two other sections, in which the same strata are prolonged from beneath the horizontal chalk, on each side of the promontory that projects towards the south, so as to meet the continuation of those which rise from the middle of the island, and with them form very flat curves. The coast thus exhibits a series of sections of almost unequalled richness and variety: and though the general characters of the strata are well known, there is still quite enough to be learned in this most interesting geological region, to repay such detailed researches as have been of late years devoted to some other portions of England, but which those only who reside near the place can carry on with complete success.

(93.) The Section, Pl. X. a. No. 7. (which is on the scale of the Ordnance Survey), shows the general order of the strata on the southern coast of the island, and, with the aid of a good map‡, will enable the reader to follow the ensuing detail. In the lower of the two lines, the heights are on the same scale as the horizontal distances.

Chalk.—The relations of the lowest beds of the chalk are best seen, on the west, at Compton Bay; and on the east, in the cliffs under Bembridge Down; both sections exhibiting admirably the passage from the white chalk to the Upper green-sand. Large portions of the chalk are pre-

* "Letters to Sir Harry Englefield," &c. 4to. 1816.

† "Annals of Philosophy," Nov. 1824, p. 367, et seq.

‡ The map annexed to Mr. Webster's letters, in Sir H. Englefield's volume, (Plate 48.) though less accurate geometrically, gives many names, and much information useful to the Geologist, which are not to be found in the Ordnance Survey.

served also at the top of the higher Downs, on the south of the island, resting on a plateau of the Upper green-sand; and the lower beds of the chalk are in many places visible in descending from these heights, as from Niton to the undercliff, and above Old Park, on the south-west of Wolverton. The gradation of hue and texture, from the whitest chalk,—through various shades of grey, and various degrees of softness, to the state of bluish marl, resembles precisely what is observable in the same part of the series at Beachy-head, on the shore near Folkstone, and on the opposite coast of France, under the cliffs of Blanc Nez.

The central ridge, or anticlinal line of the chalk, it will be remarked, is neither continuous nor rectilinear; but is divided, about the middle of the island, between Carisbrook and Shorwell, by a tract of irregular ground, intervening between two nearly parallel branches of the chalk range about three miles apart. The first, or southernmost, of these branches runs directly from the Needles to Brixton-down; the more northern from Arreton-down to Bembridge-down and Culver-cliff. The course of the principal streams of the island is transverse to that of the central chalk range: the river Medina, which nearly bisects the island from north to south, rising high upon the sands, about Stroud Green on the south of Kingston, and running almost directly northward to the estuary at Cowes. The other principal stream, the Eastern Yar, springs beneath the southern chalk, about Whitwell, not far from Niton; and after a tortuous course, instead of joining the sea in Sandown Bay, it cuts through the ridges of the green-sands and the chalk, between Yaverland and Brading. The egress of the streams, therefore, is here analogous to that already described in Kent and Sussex: and this effect may not improbably be ascribed, in both cases, to fissures, by which the lines of drainage were in the first instance determined.

Upper Green-sand.—This formation is but partially disclosed along the base of the central ridge of chalk; but is distinctly seen in the sections at Compton-bay, and on the south of Bembridge-down, and in several places along the escarpment of the undercliff*; the course of which, it is to be observed, is not exactly parallel to the anticlinal ridge, but oblique to it, running towards a point about 17° south of west. The total thickness here, in some places approaches to 100 feet, and on an average is not much less than 70 feet: its step-like projection beyond the chalk, as in Western Sussex, is conspicuous in several places, especially beneath St. Catherine's Down. One of the most accessible sections is in the ground rising above the ravine at Luccombe, where the road from Shanklin to Bonchurch crosses the strata obliquely. About the middle of Old Park is a continuous section of beds, apparently undisturbed and more than $\frac{3}{4}$ of a mile in length, rising very gradually towards the south, or west of south, and consisting above, for between 30 and 40 feet, of subcalcareous sand and stone, alternating with chert in concretions,—and below of similar sand, with spongiform masses, like those of the upper part of the sections near Folkstone; (21.) and (22.). But one of the best sections, perhaps, of the Upper green-sand, is visible above the road from Niton, towards Blackgang-Chine, over the Sand-rock spring. The brow of the cliff at that place is about 591 feet above the sea†; and the beds composing the vertical face at top, which is itself more than 100 feet high, may be thus divided:

Alternations of soft subcalcareous stone, with concretional chert. . .	30 to 40 feet.
Yellowish grey sand and stone, with some chert.	60 — 80
Alternations of yellowish grey and bluish stone, and sand.	15 — 20

* As above Western Lines; above St. Lawrence, where the road comes down from the interior, and thence westward; between Rans and Marables. At the place last mentioned the precipice is about 60 feet high, with gault beneath, and is traversed obliquely by a footpath up the whole face.

† Englefield and Webster, p. 238.

Gault.—This stratum consists, in the Isle of Wight, of dark, bluish grey, harsh, sandy clay, interspersed with minute particles of mica: but I did not discover, anywhere, the beds of light bluish, plastic clay, like that of Folkstone, which abounds in the characteristic fossils, and which, I believe, forms the lower part of the formation. The clay here, which seems not to exceed 70 feet in thickness, contains very few fossils, and these, from their imperfect preservation, are difficult to obtain. The tract, however, which this stratum occupies has been very little explored. One of the best sections of the gault which I saw, was at East-End, between Luccombe and Bonchurch, where the clay contains nodules, and branching crystalline rods of pyrites, some thin shells in fragments, and minute crystals of sulphate of lime, perhaps produced by decomposition. The top of the sands beneath this stratum, here slopes both towards the west, and outward, towards the sea; so that on the melting away of the gault, everything favours the subsidence and ruin of the upper part of the cliffs.

Lower Green-sand.—This stratum, which forms the principal portion of Mr. Webster's 'Ferruginous Sands,' occupies a great part of the surface on the south of the Isle of Wight, and is everywhere conformable to the chalk; a ridge of highly inclined strata of sand parallel to that of the central chalk, crossing the island, from the shore on the south of Bembridge Down to the foot of Afton Down. The sands are then reflected southwards, and form the lower ground in the interior, from Mottestone, through Brixton, Shorwell, Kingston, Godshill, and Newchurch, to the coast. Throughout the greater part of the shore at the 'back of the island,' this stratum is either below the level of the sea, or concealed by the debris of the undercliff; but where it rises,—westward from Rocken-End, and eastward from Bonchurch Cove, it exhibits the most distinct and fully developed sections.

When I examined the Isle of Wight, I was not aware of the subdivision of the Lower green-sand into the groups, which I afterwards found to be so well displayed in Kent (16, &c.), and Western Sussex (72.); but from the map of the island, and the characters of the strata on the coast, I have no doubt that it exists also here. A range of heights from Kingston to Walpen, which in the Ordnance Map is a very prominent feature, and seems to be continued to the shore between Walpen and Whale Chines, appears to be the outcrop of the upper member of the formation; and the heights on the south of Chale seem also to belong to this uppermost or ferruginous subdivision; while the darker beds of Shanklin and Blackgang Chines must represent the middle, or more retentive group: and even among the highly inclined strata of the Red-cliff, in Sandown Bay, green, mud-like, beds are distinguishable in the corresponding part of that escarpment. A bed at the bottom of the cliffs, both at Atherfield, and on the east of Shanklin, which abounds in fossils, especially the *Gryphæa sinuata*, is probably the equivalent of the lowest group of stone at Hythe. The total thickness of the Lower green-sand in the Isle of Wight may be considered as about 300 feet.

(94.) *The Wealden.*—The Purbeck strata do not make their appearance in the Isle of Wight; and the two remaining members of the Wealden pass into each other by insensible gradation, the Weald clay constituting but a small proportion of the whole. A valley or depression, however, corresponding to the site of the clay, is still a well-marked natural feature: the escarpment of the green-sands projecting over it on the one hand; while on the other, the Hastings sands rise into a small prominence, even in the compressed section of Sandown Bay; and form, on the west, an undulating, dome-shaped ridge, between Barne's Chine and Compton-Grange Chine, the section of which corresponds to that of these sands on the Sussex coast.

The affinity in mineralogical composition,—indeed in most of the characters except the species of the fossils which they contain, between the strata in this portion of the series in the Isle of Wight, and those above the chalk on the north of the island, is exceedingly striking; though the groups are separated by the entire mass of the green-sands and the chalk. In both we find reddish and variegated sandy marls, of various and similar shades of tea-green, purplish, and grey; in both, also, beds of sand and of grit*; and in both series, too, is an alternation of beds containing marine fossils, especially Oysters, with strata which abound in Paludina, Cypris, and other productions of fresh water. The inferences from these facts are now so obvious, that nothing, it would seem, but the strongest prepossessions in geological theory could so long have kept them out of sight†; and the proof they furnish of the repeated submersion and re-elevation of the land, is irresistible.

(95.) On the other hand, there is a very obvious resemblance, in mineralogical character, between a great proportion of the deposits, both above and below the chalk in the Isle of Wight, and the reddish and variegated marly sands of the new red sandstone (red marl), of England. Nothing can better prove the insufficiency of mineralogical characters, as a ground of identification in geology, than this close resemblance in the productions of periods so distant; while it demonstrates also the permanence and uniformity, both of the substances out of which the strata have been composed, and of the operations which produced their aggregation‡.

Weald Clay.—This stratum is visible on the coast, in one of the sections at Sandown Bay, and in both of those on the west of Rocken-End, forming a narrow band of comparatively low and flat ground,—encircling, and, as it were, insulating the Hastings sands, which rise from beneath it into heights of small elevation. In Sandown Bay, the most eastern portion of the clay, which

* Grit, not in itself distinguishable from that of Hastings, and containing Paludinæ, occurs on the north-east coast of the Isle of Wight, near Cowes. See Mr. Webster's "Letters," &c. p. 321; —and "Annals of Philosophy," 1824, vol. viii. p. 379.

† Soon after my examination of this part of the Isle of Wight, I had the pleasure of a visit there from M. Constant Prevost; and the following passage in one of his letters, written on his return from an excursion to the west of the island, coincides precisely with what is mentioned in the text:—"La succession des couches rappelle tout-à-fait celle de même nature, que sur une échelle "moins grande recouvre la craie, ou mieux est posterieure à la craie, à Alum Bay: c'est la même "disposition générale, le même assemblage de couleurs, les alternatives de sable et d'argile avec "lignite, les mêmes septaires, &c.; tout est analogue dans les deux series, à l'exception des "fossiles. On peut retrouver une analogie aussi forte entre les argilo-sables (Hastings sands) "inferieurs à la craie, et la grande formation du nouveau gres rouge; les argiles verte, jaune, et "rouge, les gres blancs et bigarrés, les conglomerats," &c.

‡ The abundance of the variegated reddish and greenish sandy clays in the upper members of the Wealden group, both here and in Sussex, is such,—and their proportion to the whole so great, that the name of the deposit might very well have been taken from them; and if the term Red-marl be retained as a general denomination, these and the new red sandstone might with some advantage be called the *Upper* and *Lower* (or first and second) *red marl*; which would indicate both their mineralogical resemblance, and their relative position in the series.

succeeds the sands of Red-cliff, is much obscured by intermixture with the ruins of several different strata fallen from above; but it abounds in the characteristic fossils. The corresponding portion of the Weald clay, on the west of the Hastings sands, between the fort at Sandown and Shanklin Chine, forms a flat shore, which is visible only at low tides. Beyond Atherfield-point, in like manner, the clay rises from beneath the Lower green-sand, and exhibits beautiful sections in the Chines immediately on the north-west of that prominence: thence it passes inland, through the lower grounds of Sutton, Thorncross, Yafford, Marsh-Green, Mottestone, Brook-House, and Compton-Grange, and meets the coast on the south of the Lower green-sand ridge, at Compton-Grange Chine; where a similar section to that of the west of Atherfield (or rather to that on the east of Sandown Bay), is exposed: but thereabouts the strata seem to have been disturbed,—whether by mere subsidence or the presence of a fault, I did not ascertain.

Hastings sand.—The general position and relations of that portion of these sands which is visible on the coast of the island (for the sections do not go down to the lowest strata), will be obvious from what has been already stated, with the aid of the section, Plate X. a. No. 7. In Sandown Bay the sands form but a small insulated spot, of an irregular figure, surrounded by the Weald clay: but on the south-west coast the superior strata of the formation are much better developed; occupying an oblong tract, approaching to the shape of half an oval, from the west of Cowleaze Chine to Compton-Grange Chine.

It will be seen from the Ordnance Map, that two small but remarkable prominences called Atherfield Rocks, and Brook Point, project beyond the general line of the shore, between Rocken-End and Freshwater Bay: so that the coast is divided into three shallow recesses, called Chale Bay, Brixton Bay, and Compton Bay; the last being, in fact, only the eastern portion of Freshwater Bay. Atherfield Rocks, and the heights on the south-east of them, belong to the Lower green-sand, of which they are the outcrop. Brook Point (or perhaps the more obtuse prominence of the shore between that place and Southmore,) is apparently the central and lowermost portion of the Hastings sands; the culminating point being much nearer to the chalk in the centre of the island, than to that on the south, in consequence of the more rapid rise of the strata in the central range. A considerable prominence, however (which, in actual elevation, is the highest point of the Hastings sands), occurs at Barnes's-high.

The rocky ledges which shoot out from the land in several places along this part of the shore, form some of its most striking features; and make this coast exceedingly dangerous to shipping. They all consist of the subcalcareous grit, which occurs throughout the Hastings sands, in concretions more or less continuous and frequently of great bulk. Similar ledges appear also, but are less prominent, in the section at Sandown Bay; and, as has been already mentioned (84.), on the coast near Hastings.

(96.) *Sectional Lists of the Strata.*—The preceding passages will enable the reader to connect the subjoined lists of the strata, in which I have availed myself of the notes annexed to three beautifully executed sectional drawings of part of this coast, by Sir John Herschel*. I shall here follow the shore

* I should gladly have inserted Sir John Herschel's sectional drawings, and my own, in place of the reduced general section, Plate X. a. No. 7.; but this could not have been done without such reduction as to exclude the greater part of their contents, and such exaggeration of the heights, in proportion to the horizontal distances, as wholly to destroy their resemblance to the natural appearance of the cliffs.

In the following list I have adopted throughout Sir John Herschel's measurement; and from the difficulty of estimating the vertical thickness of the strata, in consequence of the varying

from east to west: giving, 1st, A section from beneath Bembridge Down to the middle of Sandown Bay; 2ndly, The opposite side of the curve, from Bonchurch Cove, eastward, towards the same point; 3rdly, The succession of beds beyond Rocken-End, north-westward, to the geological centre, or lowest point, on the south-west range of the coast; and 4thly, The series from the chalk under Afton Down to Brook Point. This will involve some apparent repetition, as the strata in all the sections are essentially the same; but it will perhaps be the best mode of assisting the inquiries of those who wish to become acquainted with this district.

(97.) *Sectional List of the Strata from the south-west of Bembridge Down to the middle of Sandown Bay.*

The Section begins at the bottom of the flinty chalk. Beds very thick and massy. The flints small and disseminated.

Paces.		*Paces occupied by each division.*
0—510.	*Lower White Chalk, without Flints.*	
0—255.	This part of the beach is occupied by ruined masses from above. The base of the cliff, where accessible, seems to consist of knobs of white chalk, bedded in a greyer mass. The stratum is defined by a layer of distant, insulated flints, which separates it from the flinty chalk above. Dip about 65°. Strike, about 6° north of west; which is very nearly the direction of the coast	255
255—510.	The finest and thickest beds of pure white chalk. Dull; not very white chalk; easily scratched by the nail. Beds, 3 or 4 feet thick; separated by layers, 5 or 6 inches thick, of chalk like the rest, but interlaced with a kind of network of very grey matter. Dip, 60° north. Strike, 74° west, almost coincident with the trend of the shore	255
350.	Inocerami, much crushed. At 450 paces, the same, but less frequent. At 500, dip, 60° north; strike, 69° west of north	
510—783.	*Marly and Grey Chalk.*	
511.	Outcrop of a seam of greyer chalk	
526.	In the grey chalk a layer of yellow harder knobs	
540.	A bed of very uniform grey chalk, 6 to 8 feet in thickness exposed	
600.	A thick bed of grey chalk, as at 540; and the same rubbly yellowish layer as at 526..	
650.	Grey chalk; thick uniform beds, 3 or 4 feet	273
700.	Grey and white chalk, in alternating layers. This alternation extends about 20 feet up the cliff, which shelves back	
750.	At a breaking away of the talus, the outcrop of the grey chalk is superbly seen. Alternating, dark grey, almost blue, layers, and white, like a striped riband. Corals occupy the lower 5 feet. [The same appearances are very remarkable at the foot of Blanc Nez, on the French coast near Calais.]	

obliquity of the section to their planes, I have stated the horizontal spaces occupied by the strata at the base of the cliff, which give at least a comparative view of their proportions. I find, from the mean of several comparisons, that my own paces (which are somewhat shorter than Sir J. Herschel's), are about 43 (strictly 42·77) = 100 feet: and in my section the Upper green-sand occupies 196 paces on the shore; the Gault 94; Lower green-sand 840; the Wealden, to the culminating point of the Hastings sand, about 2000;—of which space the Weald-clay may be 600, and the Hastings sand about 1400, from their first rise to the middle or top of the saddle.

Paces occupied by each division.

783—900. *Upper Green-sand*..... 117

[The rise of this stratum is here very distinct in the section on the shore; and its course inland is marked in the original Ordnance Map (scale, 6 inches to a foot,) by a distinct ridge parallel to that of the chalk, passing from the shore close to the little village of Yaverland, on the north.]

783. Here the green-sand crops out, in a bed 20 feet thick, of very dark grey, sandy, calcareous layers, with concretions of harsh lime-stone .....20 feet.

787. Fine specimens of coral.....

800. A thick bed of green-sand, with *Siphoniæ*. In 3 feet the fossils change, the corals disappear, and the *Siphoniæ* come in. In this bed is a layer, 1 foot thick, of very black chert.

850. A darker set of layers, 1 foot, rises among the green-sand beds .....

900—1020. *Gault.*—A blue-grey marly mass, almost like the lowest beds of the chalk, but more mud, or silt-like. Harsh to the touch 120

[I could obtain no specimens of the fossils, which were few and broken. The slope above this stratum is covered with grass.—F.]

1020—1767. *Lower Green-sand*..... 747

1020. Reddish brown sand rises; small rolled gravel, and quartzy pebbles. Trend of the shore, 16° 30′ south of west. Dip, 70° north. Strike, 74° west. Thickness, 30 or 40 feet.

1061. Yellowish grey mud; outcrop (presumed) concealed by rubbish; over blue mud, passing into grey, and much mixed .....

1100. Vivid yellow sand, 6 feet. Light grey mud, 8 feet. Blue mud, 15 feet 29

1140. A great bed of dull brown sand. 1st subdivision, = 15 feet. 2nd, = 20—25 feet. 3rd, = 30 feet; brown and green-sand, and quartz pebbles, and bits of iron-stone. The lowest 3 feet very green-sand 65

1200. Deep brown sand, full of bits of oxide of iron, of a strong resinous lustre and high polish. The upper 3 feet rather less brown. [Like that which abounds in the Lower green-sand of Western Sussex and Surrey; (59.)] 58

1250. The cliff becomes mural.

1258. Presumed outcrop of pale yellow sand. Mere sand; no cohesion: has a few broken shells .....Thickness, 40 feet. 40

1323. Red sand, but not so dark as at 1200. A vivid stripe of orange and yellow. Thickness, 20 feet.

1341. A continuation of the last, separated by a rather honeycombed line. Apparent dip = 23° .....Thickness, 50 feet. 100

1406. A mere continuation of the last, separated by a dotted line, but same material. [The sand-rock hereabouts is divided, by fissures, into masses approaching to rhomboids.] Thickness, 30 feet.

1470. Outcrop of a very thick bed of dark grey mud or silt, contrasting strongly with the red sand which overlies it. Apparently the equivalent of the middle, more cohesive, greener, and less stony member of the Lower green-sand, like that of Folkstone (24—28.)? The darker sand here gives a green streak, when scraped or struck with the hammer.]

1600. The cliff loses its mural character, and falls back into an amphitheatre, full of the rubbish of the bed above .....

1676. A very red (almost blood-red) seam, a foot thick, visible in the rubbish of the beds above .....

1710, &c. *Wealden.*

[A fresh range of low sectional cliff commences on the beach at 1710; the amphitheatre of the higher cliff retiring far back,—perhaps from the rise of the *Weald-clay*; the decay of which, and its efflux in the form of mud, seems to have produced the ruin and fall of the upper strata.]

Paces occupied by each division.

1767—2150. Black slaty clay, with layers of sandy stone 2 inches thick, formed of agglutinated leaves, like sheets of paper.
[Apparently the same alternation as that which abounds on the confines of the Lower green-sand and Wealden group, described (83.), p. 168.]

1850. The amphitheatre of the retired cliff has again come round to the beach.....

1880. Layers of small flat oysters, agglutinated by calcareous matter, very like one of the beds between Atherfield and Shepherd's Chine. [See hereafter, 5580, p.197.] .....

1900. The apparent dip of the strata is now much less, = 10° .....

2000. The stratum here is like mashed slate; but earthy and incoherent, with stony layers occasionally .....

2100. Very clayey: the stony layers, when broken, appear to be very white indurated clay; but their old cracks, dark blackish brown.....

2132. Like slates; as thin as paper, but friable .....

2150. Sand. Upper 2 feet stony. Red layers of stone and rubble mixed. Apparent rise of the strata 2° or 3°; but they dip back 10°. [*Quæ.* Commencement of the *Hastings sands*?] 370

2400. A very pale sandstone. Outcrop concealed .....

2520. Mixed red and brown-yellow clay: no fossils. The strata still rise from the east. Trend of the beach, 19° south of west; and so, forward to the Fort, and back to the cliffs.

2700. Grey and red clay. No fossils.

2894. Red clay. Strata still rising at an angle of about 12° from the east.

3000. Shore too low to show the strata distinctly.

3240. A layer of tough gritty sandstone; horizontal, or rising a very little to the south-west.

3300. Another layer of tough gritty sandstone, on the beach.

3330. *Culminating point of the saddle.* Strata almost exactly horizontal. The red clay is seen resting on the stony layer of 3240 and 3300.

3400. The strata now begin to dip 1° *towards the west.*

3506. The first wooden barrier to stay the shingles on the beach near Sandown Fort.

3535. Red clay, resting on stony layers strangely contorted. The same clay also underlies them. These contorted layers extend 50 paces.

3617. Third wooden barrier. Here the grass comes down to the beach, and an embankment begins at high-water mark.

3700, the fifth wooden barrier.	3782, the seventh barrier.	3862, the ninth barrier.
3741, the sixth.	3821, the eighth.	Here begin zigzag weirs.

4050. In a line with the eastern edge of the south-east point, or bastion, of Sandown Fort.

(98.) The junction of the Lower green-sand with the Wealden strata is one of the most interesting points in the sections upon this coast, from the importance of determining whether the transition from the freshwater to the marine strata was gradual or abrupt. As far as my own observations have gone, the change, in all the sections of the Isle of Wight, is unaccompanied by any marks of disturbance, or any variation in the characters of the strata themselves, and can in fact be learned only from the total change of the fossils: a few feet in thickness, of beds conformable with those both above them and below, dividing the strata which abound in Cypris and Paludinæ, from the

lowest members of the green-sand formation, which contains shells of many different marine genera in great numbers;—Trigonia, Gervillia, large Gryphites, especially *G. sinuata,* with others decidedly marine. The bed which contains these fossils is apparently the equivalent of the lowest stone beds of the coast near Hythe, and is detached from the ferruginous stone at the top of the Lower green-sand, by a mass of soft, dark, sandy clay, which seems to correspond to the middle group of Kent.

The strata on the west of Red-cliff are so much obscured by the washing away and ruin of the clay beneath the green-sands, that no continuous section is observable here. An obvious depression, however, corresponds to the site of the Weald-clay; and both the clay and the sands which rise from beneath it include their characteristic fossils in great abundance and perfection, and contain the same large proportion of reddish and variegated marly and sandy clays, with occasional beds of subcalcareous grit, as on the Sussex coast. The following details may be added to what is stated in the preceding list.

The upper part of the clay abounds remarkably in *Cypris Valdensis*; and contains some nearly continuous bands of clay iron ore, in elongated flattened nodules, two to nine inches in thickness, including clusters of *Paludina elongata.* The beds above this clay form as it were the transition into the green-sand formation, consisting, for some feet, of alternate layers of greenish and grey sand and sandy clay of different shades, like those described above, (83.). A vertical portion of the cliff at the top of the clay, which was exposed to a thickness of between 30 and 40 feet, consisted of the following substances:

		Feet.
Greenish-grey sand and clay in alternate bands		10 0
Clay and sand with iron ore		2 0
A band or course of iron ore, with Cypris	0 8	
Greenish-grey sand, alternately of dark and lighter hues		
Bluish slaty clay, abounding in Cypris		
Clay iron ore, about	0 8	
Slaty and sandy clay		
		20 0
A bed of dull, solid, earthy calcareous stone		0 9
Greenish-grey sandy clay	7 0 to	8 0
Sand-rock, in some places very ferruginous		
Total, about		40 0

About 770 paces from the bottom of the Lower green-sand, a bed of sand-rock, from 12 to 14 feet thick, makes its appearance: perhaps one of the courses of sand, subordinate to the Wealden, indicated in Western Sussex by Mr. Martin.

In this upper part of the Wealden is at least one thin bed of limestone, consisting principally of the shells of a species of oyster (or Gryphæa?), of which I could not find any distinct specimens. It is invested with a thin crust of fibrous, somewhat earthy, carbonate of lime, having the appearance of what has been called "Cone in cone." In one loose specimen of this limestone, I found a fragment of an Ammonite, evidently derived from some more ancient stratum, washed down and lodged in the mud of which the whole of this formation is composed. The fragment is too small to indicate the species, but the genus is perfectly clear.

I did not find among the strata any one containing *Paludina vivipara*; but on the beach were several loose blocks containing that fossil, with *Cypris Valdensis*, and not distinguishable from the stone of Bethersden in Kent,—the "Sussex Marble."

About 1800 paces from the Lower green-sand, a large block of sand-rock on the shore had the waved surface, or ripple mark, which is common throughout the upper part of the Hastings sands: and here the alternations of greenish grey sand and sandy clay, so frequently mentioned above, are again very conspicuous.

About 1950, was a mass of indurated clay iron ore attached to a nodular portion of hard siliceous grit, containing moulds of large Paludina, filled with sparry sulphate of barytes: a fact which accords with the supposed continuity of deposition of the Weald-clay and the Lower green-sand; sulphate of barytes being found, it will be remembered, in the fuller's-earth of Nutfield, at the bottom of the latter formation*.

About 2040, are strong beds of sand-rock including concretions of hard grit; and thence westward the entire cliff is composed of reddish clay and sand. From this part of the series, which seems to correspond to the strata near Brook Point, on the south-west coast of the island, it is probable that the remains of the Iguanodon have been derived, of which Dr. Buckland has given an account in a paper read before the Geological Society†: and near the same place beds arise of purplish red and variegated clay, alternating with fuller's-earth of a clear bluish green colour, mixed with cohesive sand.

(99.) *Strata from Bonchurch Cove to the middle of Sandown Bay.*

The direction of the coast on the south of Sandown Bay, from the Fort to the south of Dunnose‡, is about 15° west of south. But on rounding that promontory the direction changes, and the general trend of the coast thence to Rocken End, is towards a point between 15° and 17° south of west, which seems to be generally the strike in the southern portion of the island; the dip being south 17° east.

The summit of the Downs here consists of *Chalk*, with the *Upper green-sand* beneath; and the subsidence of the *Gault* has produced very extensive ruin, especially at East End and thence to Luccombe; the debris there affording numerous fossils, among which were the following:—*Ammonites Rhotomagensis, A. Seliguinus, A. varians, Gryphæa vesiculosa, Inoceramus tenuis, Mya mandibula, Ostrea spinosa, Pecten orbicularis,* Serpulæ, *Vermetus Polygonalis.*

The *Lower green-sand* rises a little on the west of the streamlet at Bonchurch-Cove, and the following subdivisions, though in a great measure arbitrary, will give a general notion of its composition.

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* Sulphate of barytes has been found also in the Upper green-sand at Worbarrow Bay, Dorsetshire.

† Proceedings, vol. i. p. 159: and Geol. Trans. 2nd Series, vol. iii. p. 421.

‡ The names of the headlands in the Ordnance Map of this part of the coast, are different from those of the Admiralty chart and of Mr. Webster's map of the island. In the former, the height between Luccombe and Shanklin Chines is called Dunnose; and the greater promontory between Luccombe and Bonchurch-Cove, (which in the other maps, above mentioned, is named Dunnose,) is called *Chine-head.* I have adopted the position assigned to *Dunnose* in the Admiralty chart. The top of *Shanklin Down*, (which is not very different from the general level of the Chalk Downs hereabouts) is according to the Ordnance Survey, 792 feet above the sea.

A. *Bonchurch Cove to a fissure north of Littlestairs Point.*

a. The top of the first group of sand, about 30 feet thick, may be traced north-eastward, and thence north, to its outcrop in the shoulder of the cliff, above a point called Horseledge, immediately on the east of Derranew. It is composed chiefly of brownish sand; but in some places reddish and yellow. It may be remarked in general of these strata, that the colour seems to depend on the accident of exposure to moisture; the recent surfaces disclosed by the falling away of the cliffs, being frequently ferruginous yellow, or even whitish; whilst in other parts of the same beds the hues are brown and dark greenish grey: the difference arising apparently from the state of the iron, which the sand contains.

b. The next group, also about 30 feet thick, is composed of dark brownish sand and sandy clay, but is bright yellow in some of its higher points. It rises at a short distance east of Bonchurch Cove, occupies the shore thence to Steel Bay, and forms the principal portion of the cliffs at Luccombe Chine, whence it is continued northward to the summit of Knock-Cliff, on the south of Shanklin Chine.

c. The bed or group which rises about midway between Steel Bay and Luccombe Chine extends on the shore to about an equal distance north of the Chine, and goes out beneath the summit of Knock-cliff. It is about 30 feet thick, generally of a dark grey and brownish hue.

d. At a place called Derranew, north of Luccombe Chine, a bed rises, of much darker hue, and more approaching to clay than the preceding. It occupies about a third of Knock-cliff, near the lower part, where it spreads into a terrace; forms the upper part of Shanklin Chine, and caps the cliff as far as the south side of Small-hope Chine, a detached portion appearing on the top of the cliff at Little-stairs Point. From this stratum masses have fallen, like those of Parham in Western Sussex, consisting of highly ferruginous sand-rock, with numerous impressions of shells (Gervillia — Natica — Rostellaria — Terebratula — Thetis — Trigonia — Turbo — Venus?). These are found in nodules loose upon the beach south of the Chine, and *in situ*, within the Chine itself, at the upper part; and the debris of these upper strata, at the foot of the cliffs between Shanklin and Small-hope Chines, afford several varieties of concretional sparry stone, abounding in green particles, like the blocks on the shore near Folkstone (20.), containing the remains of an Astacus, Corals, and Spatangi, with shells of the genera Ostrea, Serpula, Sphæra, and Trigonia.

e. A bed or group, not very prominently distinguished from the last, rises immediately on the south of Knock-cliff. It is in general of a dark greenish, mud-like hue, contains a great proportion of silicate of iron, and seems to correspond to part of the middle group between Sandgate and Folkstone. This occupies about a third of Shanklin Chine, and forms the upper portion of Small-hope Chine, whence it declines a little to the chasm at Little-stairs Point, by which it seems to be cut off abruptly.

f. Appears above the sea on the south of Shanklin Chine; forming, as it rises, a terrace covered with the debris of the upper strata, as far as Small-hope Chine, where its top is about 22 feet above sea; and then declines to the fissure near Little-stairs Point. It consists of an intensely deep green, almost black sand, (no doubt a part of the middle group of Folkstone), and in many places contains very fine specimens of *Gryphæa sinuata.*

Immediately on the north of Little-stairs Point, about 800 paces north of Small-hope Chine (and about 1600 from Shanklin Chine) is a remarkable break or fissure: and here Sir John Herschel found reason to suppose that a fault exists, the strata on the north of the chasm not correspond-

ing with those on the south of it. The occurrence of such faults is highly probable, from the proximity of this place to the great displacement in the central ridge of the island*.

Hence to the end of this cliff, in Sandown Bay, the beds rise more rapidly than in the preceding part of the section, from Bonchurch; and the order, in Sir John Herschel's sketch, beginning at the fissure, is as follows:

B. *From the fissure to the middle of* Sandown Bay.

Paces.

0—580. The cliff, about 100 feet high, which forms the north side of the fissure, consists of three portions.

1. Bright yellow sand, which goes out at 400, perhaps a continuation of *e*, last page? :
2. Deep muddy green, almost black sand or silt, (perhaps a continuation of *f*?) going out at top about 580. The beds 1 & 2, together, occupy about a fourth of the cliff, at the upper part.
3. A thick stratum of sand of various hues, cut off by the fissure on the south, but occupying the shore thence to about 600: the bottom rising rapidly, and going out near 1400 at the top of the cliff, which is there about 110 feet high. This stratum is subdivided thus:—

a. Sand, dark red and dull brown, with a greenish tinge; entirely cut off by the fissure, not coming down to the shore.

b. A thicker bed of sand; at the bottom dull greenish and dark grey,—but, as it rises, of a vivid yellow, in some places tinged with red. Dip, about 3° at the bottom, about 2° at top. Contains *Gryphæa sinuata* in great numbers.

c. Vivid yellow sand, harder than *a* and *b*; rising on the shore at 420, and extending thence to 580. Dip, 3°.

580—1100. A great bed of sand, dull dark grey on the shore, but at the upper part lighter, and near its disappearance bright yellow. This bed is much subdivided as it ascends; the lowest subdivision consists of transversely disposed layers (*false stratification*), on which those above rest unconformably, indicating either an inclined beach or some peculiarity of deposition. Goes out at top at 1750.

1100—1268. Sand; grey at the bottom of the cliff, bright yellow at top. Goes out about 1780.

1268—2000. A very thick bed or group, consisting of sand, and very sandy clay or silt. Goes out at top, about 2150.

1268—1630. A very dark sand or silt, of a deep dirty green, or almost black colour.

1500. Dark arenaceous clay, with yellow and green efflorescence. Dip, 5°—10°.

[The cliff, from 1780, northwards, declines rapidly in height.]

2000. Sand, luteous yellow, without cohesion.

2000—2160. A clayey sand, or rather arenaceous clay,—dirty brown silt; yellow at the upper part: about 20 feet thick. The bottom goes out, at the top of the declining cliff, about 2270.

2160—2300. Yellow sand.

2300. Dull yellowish sand, with thin blackish layers. Apparent dip, about 25°.

2350. Bright yellow sand.

2400. The coast bank is of sand, 15 or 20 feet high. The cliff ends here, and the flat begins. A low sand-hill commences about 2436. (*Quæ.* loose blown sand?)

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* My own section, however, ascribes the more rapid rise of the beds on the north of the prominence at Little-stairs Point, to the change in the direction of the shore; which brings the face of the cliff more nearly into the line of the greatest inclination, and makes the dip appear to be greater than before.

Paces.
2700. The King's Head Inn, at Sandown, by Sir John Herschel's measurement, is 2700 paces from the gap or fissure at Little-stairs point.

The coast, from the end of the cliff above mentioned, to a point about 400 paces north of the Fort, is a dead flat, occupied by the Weald-clay, which is visible at low tides on the shore beneath the Inn, and thence southward.

At 364 paces north of the Inn, beds of ferruginous (Hastings) sand first make their appearance, rising from beneath the clay, which dips to the south-west at an angle of about 5°: this being the descending side (on the south-west) of the curve, of which the summit is at 3330 of the preceding list, (97.).

(100.) *Strata on the South-west Coast of the Isle of Wight, from Blackgang Chine to Brook Chine.*

At the west end of the back of the island, the Lower green-sand makes its appearance beneath the Gault, a little to the east of Puckaster Cove, where the sands are ferruginous. I have no sections from that point to Blackgang Chine, a space much obscured by ruins fallen from above: but thence westward, the sections, from about the middle of the Lower green-sand to the lowest beds of the Hastings series which appear above the sea, are probably the most complete and the best developed that anywhere exist in England. In the following list, the numbers, as far as Cowleaze Chine, are taken from Sir John Herschel's sections, and the descriptions from his notes, with additions from my own.

A. *Blackgang to Cowleaze Chine.*

In the broken ground above Blackgang Chine, whitish sand-rock is visible immediately beneath the Gault, above the Sand-rock spring*, which breaks out about 150 feet above the sea, and apparently about 50 feet below the top of the green-sand, from whitish sand, containing much lignite in small fragments, with a considerable depth beneath of dark and ferruginous sands mixed with clay. There can be little doubt that these upper beds which form the shore between Puckaster Cove and Blackgang Chine, belong to the uppermost group of this formation. (See above (16.) et seq.) The same beds form also the heights about the village of Chale, and seem to extend from that place from Walpen to Kingston, as already mentioned, (93.) p. 184.

The strata immediately over Blackgang Chine, rise upon the shore at a considerable distance to the east†. They consist of the following substances:

* A full account of this spring, by the late Dr. Marcet, has been published in a former volume of these Transactions, (1st Series, Vol. I. p. 213, &c.). It is remarkable for the extraordinary quantity of saline matter which the water holds in solution;—no less than 107 grains in 16 ounces; of which 41·4 are sulphate of iron; 31·6 sulphate of alumina. The saline matter in one of the strongest mineral waters previously known, at Horley Green, near Halifax in Yorkshire, is only 40 grains in the same quantity of water. The water of the streamlet at Blackgang Chine itself is pretty strongly impregnated with sulphate of iron.

† The gravel on the beach along this part of the coast consists, in a great measure, of small rounded fragments of chalk flint; which, from their incessant agitation under the surge, are worn, and almost polished, to such smoothness and mobility, as to render it extremely laborious to walk there.

[*Lower green-sand.*]

1, 2. Loosely coherent sand and sand-rock.
3. Dark sand or silt, like loose black mud.
4. Sand-rock like 1 and 2, in homogeneous blocks.
5. Black mud-like sand.
6. A great bed of sand, loosely coherent, like 1, 2, and 4, in blocks about 6 feet thick.
7. Loose black mud or silt, much like 5.
8. Mere loose sand, without cohesion.
9. Black earthy sand, rising on the shore about 900 paces east of the Chine, and forming the bed over which the streamlet falls.

In the following detail of the strata, the distances are measured, in both directions, from the middle of the Chine, as being one of the most remarkable points of the shore.

Paces. *Thickness in Feet.*

850 to 560,—east of the Chine. Yellow agglutinated sand above, passing below into a dark muddy silt. It has no green earth in it. This bed forms the upper stony-looking layer over which the water falls at the Chine. The bottom goes out at 350 paces west of the Chine; 15—20 feet thick. — 20

0. Middle of *Blackgang Chine.*

560 east, to 240 west of the Chine. Sand, full of green earth. The second or middle stony-looking bed of the fall, which has there a convex surface. ..... Bottom goes out at 590 west of the Chine — 20

240 east, to 400 west of the Chine. Very dark or almost black sand, forming the base of the cauldron of Blackgang; coloured red externally by the action of water and air on the ferruginous matter which it contains. .....Goes out at 1040 west of the Chine. — 15

400 west of the Chine, to 520. Black slaty clay or mud, like mashed slates, without solidity of aggregation; decomposes into muddy earth. .....Goes out at 1130 west. — ?

500. Hereabouts are very remarkable stems of Siphoniæ.

[This part of the shore, about 500 paces north-west of the Chine, is called *Cliff-End.*]

520 to 614. Green-sand closely intermixed with ferruginous layers and much pyrites, which give it compactness and solidity.....Goes out at 1420 west. — 5

614—768. Three feet at top, forming a transition from the last stratum, by alternation with the following. Below, 10 feet consist of deep green, almost black, and very uniform sand; without fossils..... Goes out at 1520. — 13

768—812. Rugged ferruginous sand, of a brown colour .....Goes out at 1580. — 7

812—1090. 1. Mixed green and yellow sand, very dark, including *Gryphæa sinuata*, in very hard tough lumps .....Thickness, 4 feet.
2. A second bed, at the bottom of which is a layer of *Gryphæa sinuata* .....1 foot.
3. Mixed brown and green sand, including detached specimens of *Gryph. sinuata*..7 feet.
The bottom of this group goes out at 1800. — 12

1090—1360. Very green sand, softer than the last. Cliff mural. Lines of false stratification at the top.....This bed goes out on the east side of Walpen Chine about 1910.

1360—1590. Brown green-sand, much like the last, but different in cohesion ..... Goes out at top in the east side of Whale Chine, at 2480.

About 1431, a copious spring has, in its fall, coloured the whole face of the cliff with a broad red streak. The whole seems to be greenish grey sand, and clay; very dark and moist. The cliff continually scales off in great flakes, which are washed away, so as not to form much talus. Red drip frequent.....

1590—1800. Sand, with layers of great flattened and oval concretions of very tough calciferous stone, 2 feet in diameter. [*Quæ.* like the Cowstones of the Devonshire coast*] .. Goes out at 2660. — 12

* See De la Beche, Geol. Trans., 2nd Series, vol. ii. p. 113.

Paces. *Thickness in Feet.*

1800—2200. Very dark sand, which, from 2100 to 2400, forms a mural cliff, standing back behind the rubbish of the next stratum below, and its own. At 2200 it is cut into a ravine (not marked in the Ordnance Map) called *Ladder Chine*: there is, however, very little of a stream from it. This stratum forms the beach-line of *Walpen Chine*. Goes out at 3010.

1950. The middle point of *Walpen Chine*.

2200—2900. Loose dark mud. It contains, especially at 2400, the large Gryphæa, but smaller than the gigantic specimens of the beds next below. The ruins of the stratum form a terrace-like projection, increasing in height gradually from 2200. Goes out at 3800.

2570. The middle point of *Whale Chine*.

2900—2948. A group of sand, the bottom of which goes out at 3710. .....

3070. A bed of fine large Gryphites, over 2 feet of sand, hardened so as to throw out the springs, which have stained its exterior a vivid red.....Thickness, 4 feet.

3100. Very large Gryphites, in the same hard, green brown sand. They occur in knobs, and are concreted firmly together. [Clusters also of Serpulæ and Terebratulæ.] .....

3146. A layer of fine Terebratulæ, strongly agglutinated in the darker green sand.....

3152. Gigantic Gryphites below the layer of Terebratulæ, at 3146.....

3170—3400. Brown sand; upper part more compact than lower. The bottom goes out at 4610.

3400—3560. Sandy silt.....Goes out at 3410. 10

[This part of the shore, which is called *Atherfield High-cliff*, strongly resembles that between Shanklin Chine and the middle of Sandown Bay.]

3560—3700. Dark mud.....Goes out at 4610. 10

3700. Hard tough sandstone, passing into the next division below, which is softer. The separation is marked by great concretionary masses, in balls or kidneys, some of them 6 or 7 feet long, and 4 to 18 inches thick, including *Gryphæa sinuata* and Perna, with small Ammonites in pyrites. Similar concretions occur also at the top of this bed, and at the bottom of the next .....This division goes out at 6070. 18

4010. Passes insensibly into the mud next below: near the junction a small Ammonite.... Goes out about 6080.?

4010—4725. A loose, incoherent, blue-grey, muddy clay. It is in a state of great ruin, and has overwhelmed the beach with a vast talus of its mud, which bases the sand-cliff at *Atherfield*, and forms a slope, on which are fishing-huts, boat capstans, and a path up to the Preventive Station, which cannot be seen from the beach. The place where this bed goes out at top is indistinct, but it seems to form the upper part of the south-east side of *Shepherd's Chine*, about 6100 .....

[This clay appears to be the equivalent of the fuller's-earth of Surrey. It is about 15 to 30 feet thick and contains very numerous fossils: Ammonites, Echini, Terebratulæ and Corals; with crystals of sulphate of lime, perhaps produced by decomposition.]

4725—4775. Brown and green sand-stone, 2 feet thick, and well defined .....

[Apparently the equivalent of the lowest beds of stone very near to the bottom of the Lower green-sand at Hythe; and here abounding in marine fossils, among which are the following genera: Ammonites, Avicula, corals, Corbula, Cucullæa, Exogyra, Gervillia, Gryphæa (especially *G. sinuata*), *Nautilus elegans*, Ostrea, Panopæa, Pecten, Pinna, Plagiostoma, Serpula, Thetis, Trigonia, Vermetus, with others of the Lower green-sand. Nothing can be more striking than the sudden contrast between such an assemblage and the fossils of the clay immediately below.] .....

The continuation of this fossiliferous stratum is still visible, high up in the ruined face of the cliff and above the clay, as far as 5700 paces .....

Paces.	[*Weald Clay.*]	*Thickness in Feet.*
4775—5700.	A mass of incoherent, muddy-brown, grey, and blue clay immediately succeeds to the last bed, and goes out in the east side of Shepherd's Chine about 6100. It has covered the beach with an immense ruin of mud, which contains the substances under mentioned. The ledge called *Atherfield Rocks*, which is visible at low water, about 10 feet below the bed of sand-rock with Gryphites, consists of blue slaty clay, including *Cypris Valdensis* in myriads, with thin portions of pyrites.....	
Between 4800 and 5000 is *Atherfield Point*; and here the course of the beach alters.		
5040.	At this point the stratification of the clay is distinctly discernible on the beach. It is deep blue black, and shivery	
5440.	Here occurs a thin seam of pyrites in large flat cakes, with rounded outlines, in great abundance. They seem to form a bed, but are individually discrete, like the flints in chalk*. The rise of this seam is not visible	
5500.	Large, well-formed, transparent crystals of selenite, 2 or 3 inches long, lozenge-shaped, not lenticular.....	
5580.	Thin stony layers of very tough limestone, half an inch thick, which seems to consist of agglutinated small oysters, the flat shells of which are chiefly visible.....	
About 5700, immediately on the west of Atherfield Point, is a deep and rugged recess, called *Tiepit.*		
5700—6220.	A thick bed (50, 60, or 70 feet) of black shaly mud, including occasional layers of tough, hard, shelly limestone, consisting, seemingly of agglutinated bivalves (Cyclades)†. The concave surfaces of the shells lie uppermost, and form the whole surface of the layers. The lower surface of these layers of stone is curiously corrugated, (or studded) with short, crossing protuberances, apparently the edges of projecting shells. The layers are one or two inches thick. There are also in this bed tough, stony, non-effervescent layers; but the general material is a blue or black clay, which breaks into thin layers, like mashed slates. [This bed constitutes the bottom and a great portion of the lower part of *Shepherd's Chine*: it rises to the top of the cliff, far to the west, about 500 or 600 paces west of *Cowleaze Chine.*].....	50—70
6220.	About this point is the middle of *Shepherd's Chine*‡.	
6220—6440.	The whole is yellow sand, but little coherent; the upper part more compact, including large pyritous balls excessively hard and tough; the lower soft and shivery. This bed occupies on the shore about half the space from Shepherd's to Cowleaze Chine. The top goes out about 900, the bottom at 1200 paces west of Cowleaze. It crosses *Cowleaze Chine* at the upper part, and thence westward rises steadily at the upper part of the cliff	
6440—6615.	Upper 7 feet shaly mud, in thin flakes; lower 3 feet black, not adhesive mud, which breaks into layers. No fossils. The whole 10 feet thick	10
6615, to about 20 north-west of Cowleaze Chine.	A stratum consisting of two layers: upper 3 feet sand; the lower 3 feet a black shaly clay, passing into the stony stratum next below. Goes out about 1500 paces north-west of the Chine	6
6650.	Is about the middle of *Cowleaze Chine.*	

* Flat, cake-like, nodules of pyrites occur in what I have supposed to be the upper part of the Weald-clay, at Peasemarsh, near Guildford in Surrey. See above (64.).

† Some of these beds of limestone break into rhomboidal pieces, the angles of which projecting in the face of the cliff, produce serrated lines remarkably contrasted with the uniform surface of the clay.

‡ It is through this chine that a streamlet, which once made its way to the shore at *Cowleaze Chine*, now reaches the sea; and the manner in which the alteration was produced, shows the facility of changes on a coast composed of materials like these sands and clays. The streamlet in the Ordnance Map is seen to rise near the village of Kingston, probably at the junction of the ferruginous upper member of the Lower green-sand with the middle retentive group (25.). It was very tortuous near the shore, and formerly came close to the edge of the cliff near its present outlet, but made its way to the beach at Cowleaze; till, the soft and narrow barrier at top having been cut through, the water soon deepened the chasm, and formed a new chine, leaving its previous bed, with Cowleaze Chine itself, deserted and dry.

[As the *Weald-Clay* and its passage into the sands beneath are better displayed here than in any other place with which I am acquainted, I shall subjoin a more detailed enumeration of the beds, collected from the successive portions of the ruinous cliff, which, when I examined the place, were well exposed on the shore at *Tiepit*, thence to *Shepherd's Chine*, and within that Chine itself and *Cowleaze Chine*. This list is still no more than an approximation; but time and labour only are required to carry the enumeration to any extent of detail: it begins almost immediately beneath the remarkable bed above mentioned as abounding in fossils (4725—4775), which may be considered as the lowest member of the Lower green-sand.]

	Ft.	In.
A group of beds, full of crystals of sulphate of lime, perhaps produced by exposure:—detail thus: *a*. Clay, with much pyrites .... *b*. Greenish and blue slaty clay . *c*. Clay and sand, in thin alternate course, including minute bones of fishes.....	12	0
Dark bluish grey slaty clay, with thin courses of very fine light greenish sandy clay	8	0
A bed of limestone, with thin oyster-shells (or Gryphites?) indistinct ..	0	3
Shale, as above, abounding in *Cypris Valdensis*, and including a bed of pyrites with *Paludina elongata*....	1	3
A course of limestone, with Cyclades at the bottom.....	0	3
Thin, paper-like courses of sand, alternating with slaty clay ..... Bluish grey shale, with small bones of fishes and some crystals of sulphate of lime	4	0
Sandy clay of a lighter hue	0	2
Bluish grey shale, with Cypris and fish bones.....	1	6
Greenish grey shale; the folia penetrated by cylindrical and vertical portions (like stems) of lighter grey sand	1	6
Flat nodular portions of very poor clay iron-ore.....	0	2
Greenish, very sandy, clay	2	0
Greenish grey sand and clay in thin courses, alternating with dark, tough, slaty clay, containing clusters or patches of *Cyclas media* with *Cypris Valdensis*	10	0
Lighter coloured slaty clay, containing Cypris; alternating with grey and whitish, somewhat sandy clay	10	0
Similar beds, including pyritous wood and pyrites, with a band of siliceous limestone, curiously embossed at the bottom with Cyclades converted into carbonate of lime (see 5700; p. 197).	7	0
Similar beds	8	0
Shale with *Cypris Valdensis*.....	4	0
Sandy clay, including a bed 6 inches thick, of great firmness.....	15	6
White sand-rock	1	6
Sandy clay and shale	8	0
Ditto, of lighter colour.....	1	0
Beds of sand and clay, including nodules of iron-ore	4	0
Greenish white sand in stripes .... 2—4	0	
Apparently light greenish sand and brownish sandy clay	12	0
Greenish grit, containing numerous empty moulds of Cyclades	3	0
Yellowish sand-rock, with lines of false stratification ..... [A line of darker hue occurs in the group. *Quæ*. Remains of bones?]	20	0

[The preceding group of grit and sand-rock, which is not improbably the equivalent of one of Mr. Martin's beds subordinate to the Weald-clay, first appears on the shore about the opening of Shepherd's Chine; and rising thence gradually westward, occupies about 20 feet in the side of *Cowleaze Chine*, near the middle.]

Beds of greenish grey sandy clay, of two shades of colour, alternating with specks of mica. A range of nodules of iron-ore is within a few inches of the top, containing Paludinæ and Cyclades.	15	0?

Total thickness about 140 feet.

I sought here, but without success, for remains of the large Saurians like those of Loxwood and Tilgate forest. Nor were there visible upon the shore any continuous masses of subcalcareous grit.]

B. *Cowleaze to Barnes's Chine; about 2150 paces.*

The strata on the west of Cowleaze Chine afford little variety and no very prominent features. The Chine cuts through the bed, or group of sand-rock above mentioned;—which goes out on the north-west of a prominence called Barnes's Hill (or Barnes's High), and probably is the cause of its durability and elevation.

0—75. At the foot of the cliff, where Cowleaze Chine opens upon the shore, a seam of hard yellowish grey sand-rock arises, which is slightly effervescent: it goes out at the top of the cliff about 1800 north-west of Cowleaze Chine. If it were necessary to assign any strict boundary to the formation, this might be considered as the beginning of the *Hastings Sands.*

75—900. A mass of reddish and variegated tenacious sandy clay next comes in, much interspersed with pyrites and containing wood-coal. It rises about 75 paces from the Chine, and occupies more than 800 paces on the shore, the top going out about 1800, and the bottom about 2000, very near to Barnes's Chine. The proportion of red and greenish variegated clay, like those of this great bed, to the sand-rock, is henceforward so great in the cliffs, that the name of *sands* is misapplied to this part of the formation. The general resemblance of the strata to the variegated marls of the new red sandstone, (*keuper* of the Germans,) has been already mentioned.

900—1050. A group of sand-rock, including in several parts of its course large nodular masses of hard grey grit, next occupies about 150 paces on the shore. It is about 15 feet in vertical thickness.

1050—1800. This space on the shore seems to be totally occupied by dark reddish, marly and sandy clay, variegated with greenish and grey, which form a large portion of the upper and middle portions of Barnes's Chine.

1800 to about 1950. A bed of sand-rock, called by the inhabitants "*Barnes's Sand-rock*", rises about 1800. It is cut through by the lower part of Barnes's Chine, and goes out far to the north-west of it.

1950. Dark reddish and variegated clay again comes in, and is continued towards the north-west.

2150, from *Cowleaze*, is the middle point of *Barnes's Chine.*

C. *Barnes's Chine to Grange Chine; 2300 paces.*

The cliff throughout this space also is very little varied. The bed of sand-rock above mentioned (1800 to 1950) rises steadily in the middle and upper part of it, crossing *Chip's Chine*, and going out at top near *Ship-ledge*, hereafter mentioned.

The dark red and variegated clay, 1950, occupies the shore on both sides of *Barnes's Chine*, and extends far to the north-west. The coast here is throughout a range of low, nearly uniform cliffs, of a dull reddish hue.

500, north-west of Barnes, is the place of *Chip's Chine.*

1000. The place of *Ship-ledge*; a group of sand-rock beds, which runs out far into the sea, and is rendered more solid by concretions of subcalcareous grit.

2300. The place of *Grange Chine.*

D. *Grange Chine to Brook Chine; 5600 paces.*

635—660. A bed of sand-rock rises at 635 from Grange Chine, and at 800 is very near the top of the cliff.

790, is nearly the place of a chasm in the cliff, perhaps *Jackman's Chine*?

1500. The middle point of *Chilton Chine.* Hence to *Bull-rock-ledge*, reddish and variegated marly sand and clay appear to form the shore.

1900—2000. A bed or group of sand-rock, beneath reddish and variegated marly clay and sand, here occupies the shore for about 100 paces, forming before it rises one of the principal ledges of the coast, which stretches far into the sea, and is called *Bull-rock-ledge*. This bed in its progress westwards is a remarkable feature in the cliff. It is from 15 to 20 feet thick, and rises gradually to the north-west; attaining its greatest height above the sea near a gap or chasm at *Southmore*, and then declining very slowly, till it comes down to the shore between 1000 and 900 from Brook Chine. It seems therefore to form a curve; which, however, is only apparent, resulting from the general rise of all the strata from the interior towards the sea, combined with the curvilinear prominence of the coast between Chilton and Brook Chines. The true relation of the beds here is explained in the transverse section, Plate X. b. fig. 4.

This sand-rock bed, in its progress through the extensive space just mentioned, is of nearly uniform character, the chief difference arising from the frequent concretion of the sand into subcalcareous grit. In several places, the fallen blocks contain cylindrical stems of Siphonia, with shells, occasionally, of the genera Cyclas, Paludina, and Unio; and the grey sand-rock includes small patches or specks of greenish clay.

The cliff beneath the apparent curve formed by the sand-rock bed, consists throughout of dark reddish and variegated marl, or sandy clay, which seems to form all the lower portion of the prominence at Southmore; the greatest height which it attains being about 30 feet above the sea.

In approaching *Brook Chine*, from the spot where the sand-rock bed above mentioned sinks below the shore, the cliff is low and partially covered with grass, but seems to consist of reddish and variegated clays.

A bed of firm grey sand-rock rises at a small angle from the south-east, about 300 paces from *Brook Chine*, which it crosses, and forming a very slight but really existing curve, goes down about 320 paces beyond it, on the north-west; the highest point being near the middle of the Chine. All below this curved sand-rock bed consists of dull red and greenish variegated clays: these are seen especially in the north-west side of the cove, or bay, which leads to Brook Chine; and the floor beneath high-water mark is composed of them.

(101.) *Strata on the South-West Coast of the Isle of Wight, from the Shore under Afton Down to Brook Chine.*

The line of the coast immediately under Afton Down cuts the strata very obliquely. The *Upper green-sand* does not offer any important difference from that of the section under Bembridge Down on the east of Sandown Bay. The following measurement commences with the rise of the *Gault*, which is distinctly marked, this stratum occupying a valley or depression between the upper and lower green-sands.

0—170 is the width of the oblique section of the *Gault*.

170—725. *Lower green-sand*:—affording nothing so different from the other sections in this island already described as to require detail.

512. The middle point of *Compton Chine*.

725—1076. The *Weald clay* (which appears on the beach below the cliff about 710), first rises distinctly above the beach at 725; and thence for a considerable space the shore is occupied by mud and fallen ruins, the remainder of the original cliff being thrown back. Blue clay, however, is visible, apparently in situ, at several points along the shore, and fragments of a thin bed of limestone full of Cyclades, are frequent.

1066. At this point a few regular beds of limestone, six to nine inches in thickness, composed in a great measure of Cyclades, and alternating with shale abounding in Cypris, are dug out of the cliff to be burnt for lime.

1076. Here beds of reddish clay or marly sand, (like those which occur below the Weald Clay on the coast from Atherfield to Brook Chine,) make their appearance, and occupy the shore to about 1850, where *blue* clay and shale are found again*.

1100. Shore much obscured by the fallen ruins of the strata.

1200. In the *remoter* cliff, beds of dark bluish shale are seen, above the reddish clay.

1200—1224. Very red clay on the shore.

1276. A bed of reddish and variegated sandy clay rises, evidently in situ; and thence to 1500, all the nearer and lower part of the cliff is composed of it, in ruins. Above, in the more distant cliff, is the blue clay of the Wealds.

1450. Reddish and variegated clay appear in situ on the shore.

1500. A bed of sand-rock of a yellowish grey colour rises. Immediately over it, at 1530, is dark mottled clay, with much pyrites and coal.

[1600—1850. An under cliff on the immediate shore.]

1630. A group of beds of sand-rock rises, about 10 feet thick.

1710. Thin beds of sand, with lignite, on the shore in the under cliff. In the remoter cliff is a small chasm or chine at the top only†.

1886. Bluish beds of slaty clay again rise on the shore, in which *Cypris Valdensis* occurs abundantly. Strata hence to the next Chine much contorted.

1980. A small opening or chasm, called "*Twenty-acres Chine*," on the east of which the cliff is about 40 feet high. At the upper part, immediately below the diluvium, are beds of bluish shale in situ.

[At the top, all along the cliff, from about 1850 to Brook Chine, is a coating of diluvial loam and gravel of a very red colour, and 10 or 15 feet thick.

All the strata in the cliffs hereabouts, from 2000 onwards, rise towards the south-east. They are visible also very distinctly on the shore beneath high-water mark. Compare these with the strata on the west of Hastings (80.) to (84.).]

2073. A strong band of *sand-rock*, 4 feet thick; thin shale 2 feet below.

2090. A bed of iron ore, about six inches thick, with Paludinæ.

2100. Sand-rock 6 feet thick; false stratification remarkable.

2140. Stony bands, in shale, with *Paludina elongata*.

2173—2185. A strong band of firm sand-rock, about 4 feet thick rises; nodules of grit at the lower part, immediately above the dark red clay.

2190. Dark reddish clay, apparently continued to 2400.

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* The weather was so bad during my examination of this part of the coast, that it was out of my power to ascertain the cause of this recurrence of the Weald-Clay, after the appearance of the sands and variegated marl. It may be no more than the effect of subsidence; and the second mass of clay, the beds of which are contorted, may have fallen from the heights above; the remoter undisturbed cliffs consisting apparently of sand at the bottom, and at the top of blue clay and shale. But, on the other hand, the existence of one or more faults might be expected in this part of the island; for it is not probable that the great mass of strata, which are nearly vertical in the central range, should return so soon to the slight inclination in an opposite direction, which they exhibit on the south, without the formation of cracks. The question is locally interesting, but does not affect the general order and proportion of the formations.

† This remote cliff was not examined, for the reason given in the last note.

2370. *Biddlecombe's Chine*; cliff on the east of it, about 25 feet high.

2400—2410. A strong sand-bed rises to the middle of *Compton-Grange Chine*, on the north-west side.

2410—2552. All reddish and variegated clay; diluvium still at top.

2462 Middle of "*Compton-Grange Chine.*"

[On the shore, at the mouth of this Chine, are large masses of angular, grey and yellowish, flint fragments, cemented by ferruginous matter. The coast from hence to Brook Point runs out uniformly in the same direction.]

2552. A strong band of reddish sand-rock; goes out at 2615.

2582—2658. Reddish and greenish clay and sand.

2658. A bed of sand-rock rises; under it is reddish matter, but concealed on the shore.

2694—2700. A bed of *sand-rock* rises, about 4 feet thick, with reddish stains and spots, like those of the new red sand-stone.

2700—2822. Dark red and variegated marly clay seems to occupy all this space.

2843—2855. A bed of fine-grained sand-rock, which forms a ledge in the sea, (the first from Compton-Grange Chine) rises about 2843, and goes out under the diluvium at the top of the cliff, about 3000, very near to *Brook Point*. It may possibly be the same with that which reappears on the other side of the point, and crosses the upper part of Brook Chine.

2855—2952. Variegated, wine-red and greenish, cohesive sand, not effervescent, occupies this space on the shore, and forms the upper part of the Point and nearly the whole of the cliff below the diluvium thence to near Brook Chine.

2952—3030. A group, consisting of sand and sand-rock, with concretions of subcalcareous grit. This forms the base of the Point; and the upper beds of the group seem to go down, beneath the variegated sand of the last-mentioned stratum, between the Point and Brook Chine. The boatmen informed me that some of the ledges of sand and sand-rock run out several miles into the sea from this part of the coast. The lower part of this group includes, in great numbers, large trunks of petrified coniferous wood*, frequently of a dark brown colour, penetrated by carbonate of lime and effervescing abundantly with acids; the cracks by which they are traversed being filled with the same substance. At very low tides, compact variegated sand, like that which abounds on other parts of this coast, appears below the sand-rock of the Point, and seems to be the lowest visible stratum of the island.

The extremity of *Brook Point* is about 3060 paces from the rise of the Gault under Afton Down, measuring along the shore; thence to the Chine the shore turns inwards a little towards the east, and the distance is about 830 paces; of which about 250 are occupied by the sand-rock of the Point, beneath the variegated clay. About 320 paces from the Chine a bed of firm sand-rock rises, and crossing the upper part of it, forms a slight curve: it is, in fact, a continuation of that already mentioned, which rises about 300 paces on the south-west of the Chine.

3890. The middle of *Brook Chine* is about 3890 paces, reckoning round the Point, from the top of the Gault under AftonDown.

(102.) *Fossils of the Beds below the Chalk in the Isle of Wight.*

[*Upper Green-sand.*]

Ammonites cinctus. East End. In grey marly chalk, with few green particles.

A———— Mantellii. Western Lines. Some of the specimens compressed into ovals.

* See Webster's Isle of Wight, p. 153—4.

Ammonites Mantellii? A variety without tubercles. Western Lines. Sandrock near Niton.
A——— *Seliguinus.* East End.
A——— *varians.* East End. Bonchurch. Grey chalk marl. Western Lines.
Belemnites. Western Lines.
Cardium. Western Lines.
Cucullæa glabra. Western Lines.
C——— *decussata?* Western Lines.
Exogyra undata. Western Lines.
Gryphæa canaliculata. Western Lines?
G——— *vesiculosa.* East End and Western Lines.
Nautilus compressus. Western Lines?
Pecten orbicularis. East End: some specimens very large.
P—— *quadricostatus.* East End. Western Lines.
Plagiostoma Hoperi? Western Lines.
Plicatula inflata. Western Lines.
Siphonia Websterii. Parkinson, Int. Org. Rem. Western Lines. Figured by Mr. Webster, Geological Transactions, 1st Series, vol. ii. pl. 27—30.
Solarium conoideum. Pl. XI. f. 14. Western Lines.
S——— ornatum. Pl. XI. f. 13. Western Lines.
Spatangus. Near the Sandrock Spring.
Terebratula depressa? Western Lines.
T——— *pisum.* Western Lines.
T——— (new). Western Lines.
Trochus. Western Lines. St. Boniface. Upper Green-sand, or Chalk Marl.
Turrilites tuberculatus. Near Bonchurch.
Venus? Western Lines.
Vermetus umbonatus. (*Vermicularia umbonata*, Min. Con.) Western Lines. Large specimens?
V——— *polygonatus.* Bonchurch and Ventnor Cove.

[*Gault.*]

Ammonites Seliguinus (syn. *A. Beudantii.*) East End.
Gryphæa. East End.
Mya mandibula. East End.
Pecten orbicularis. Compton Bay: In harsh gritty Gault.
P—— *quinquecostatus.* Compton Bay.

Fishes. Obscure impressions of. East End.

Plants. *Fucoides Targionii.* (Ad. Brongniart, "Végétaux Fossiles," Pl. IV. fig. 6.; and Mantell, "S. E. of England," p. 166.) East End.

[*Lower Green-sand.*]

Ammonites furcatus. Pl. XIV. fig. 17. Atherfield.

Astacus. East of Shanklin.

Astrea. East of Shanklin Chine, and Atherfield Point: in fuller's earth.

Corbula striatula. West of Shanklin Chine, in ferruginous nodules, with many other fossils. Near Atherfield.

Exogyra conica? Atherfield Point.

Gastrochæna. In Coral, near Atherfield Point.

Gervillia aviculoides. West of Shanklin Chine. Atherfield Point.

G—— solenoides. Same place: in ferruginous nodules.

Gryphæa vesiculosa? Sandown Bay: in a mass of yellowish sand, with polished fragments of brown iron ore.

G—— sinuata. East of Shanklin Chine: in ferruginous sand, with dark particles and fragments of iron ore. Frequent on the east of Atherfield Point. Near Niton: very large.

Inoceramus concentricus. Near Atherfield: in fuller's earth: in sandy stone, with vegetable impressions (*Fucoides Targionii?*).

Lingula. Barnes's Chine. Isle of Wight?

Modiola depressa? Near Atherfield: in fuller's earth.

Mya plicata. (See *Panopæa.*)

Natica. In ferruginous nodules, West of Shanklin Chine.

Nautilus radiatus?. Near Atherfield. This and other specimens from Kent very much resemble *N. radiatus*, from Malton, Yorkshire. It is very distinct from *N. elegans.*

Ostrea carinata. East of Shanklin. Atherfield Point: in green sand and in the fuller's earth.

O—— macroptera. Near Atherfield.

Panopæa plicata. Atherfield Point. East of Shanklin: with Serpula.

P—— (new). Atherfield.

Pecten obliquus. Atherfield Point, with *Terebratula Sella.*

Perna quadrata? Fallen masses on the shore east of Shanklin Chine.

Pinna tetragona? Atherfield Point: in fuller's earth.

P—— (new species?). Near Atherfield: in green sand, like the middle bed of Sandgate, Kent.

Plagiostoma elongatum. Atherfield Point: in fuller's earth.

Rostellaria calcarata. Shanklin, top of the cliff, west of Chine: in ferruginous nodules, with many other fossils.

Rostellaria Parkinsonii. Shanklin: in ferruginous nodules. Same situation.

Serpula antiquata? Atherfield Point: fuller's earth.

S——. Another species, with *Ostrea.* Atherfield. Cowleaze Chine.

Spatangus. East of Shanklin. Atherfield. Cowleaze Chine? fuller's earth.

Sphæra corrugata. Shanklin, (large specimens.) Sandown Bay.

Siphonia. Near Atherfield Point: in green sand.

Terebratula biplicata. Chale Bay.
T.——— Gibbsiana. Atherfield Point.
T.——— latissima. Near Atherfield.
T.——— nuciformis. East of Shanklin.
T.——— Sella. Sandown Bay. Atherfield Point: in greens and, and in fuller's earth. With *Pecten obliquus*; Chale Bay.
T.——— parvirostris. Pl. XIV. f. 13. Debris on the shore east of Shanklin.
Thetis major. Atherfield Hill. Blocks loose on the shore.
T.—— minor. In ferruginous nodules, west of Shanklin Chine.
Trigonia alæformis. East of Shanklin; of unusually large size: and in ferruginous nodules, west of the Chine. Atherfield Point; large, in sand very like the middle Sandgate bed.
Turbo conicus. West of Shanklin Chine: in ferruginous nodules.
T.—— rotundatus? Shanklin.
Turrilites? Near Atherfield.
Vermetus concavus. With *Terebratula Sella*: Atherfield; and east of Shanklin.

[*Wealden.*]

Ammonites. A fragment imbedded in a portion of Sussex marble, with Cyclas, Ostrea, and *Paludina elongata.* This Ammonite probably formed part of a foreign mass accidentally brought into the Weald clay, during the progress of its deposition.
Cyclas major. Atherfield Rock, in Sussex marble and Weald clay: also forming singular prominences on thin layers of stone; see p. 197 line 24, and p. 198. Cowleaze Chine. In ironstone, west of Shepherd's Chine. Barnes's Chine, very large. Compton Bay.
C.—— media. Sandown Bay. Atherfield Rock, about 2 inches thick, in a bed almost composed of these shells, incrusted with fibrous carbonate of lime. West of Shepherd's Chine: in coarse ferruginous sandrock, probably one of the subordinate beds of the Weald clay: in pyrites. Cowleaze Chine. Barnes's Chine.
C.—— membranacea. Sandown Bay: large, preserving its iridescence. Near Atherfield. Shepherd's Chine. Barnes's Chine.
C.——. (A thick and gibbose species.) Sandown Bay in ironstone.
Cypris Valdensis. Pl. XXI. fig. 1. Occurs throughout the Wealden. At Sandown Bay; Atherfield; Shepherd's Chine; Cowleaze Chine; Barnes's Chine; Under Barnes's High; Brook Point; Compton Bay.
Cypris tuberculata. Pl. XXI. fig. 2. Near Atherfield and Cowleaze Chine.
Modiola (new). Sandown Bay.
Ostrea. A bed of limestone nearly composed of oyster shells occurs in the Weald-clay at Sandown Bay; near Barnes's Chine; and on the west of Compton-Grange Chine.
Paludina acuminata. Near Atherfield. Near Barnes's Chine (young).
P.——— elongata. Occurs throughout the Wealden. Sandown Bay: in ironstone. Atherfield Rock: in clay. Tiepit, near Atherfield. Cowleaze Chine: in no-

dular masses of ironstone. West of Shepherd's Chine. Near Barne's Chine: in stem-like masses of pyrites. Under Barnes's High. West of Compton Chine.

Paludina fluviorum. Sandown Bay, with Ostrea, Cyclas, and *Paludina elongata*: in a course of stone, about 2 inches thick: also with *Cypris Faba*, in similar stone.

Potamides? In clay, Sandown Bay.

Remains of Fishes. Scales of one or more species of Lepisosteus, (Lepidotus of Agassiz,) apparently the same with those which are frequent in the Wealden of Kent and Sussex, are found in the Weald-clay at Sandown Bay: as are also the teeth, vertebræ, and other bones of some small species of fishes, at Sandown Bay; near Atherfield Point; and at Cowleaze Chine.

Large concretional masses with small tubular erosions on the surface, much resembling those of Sandgate in Kent (13.), containing a large proportion of phosphate of lime, and affording during solution the smell of *Coprolite*, have been found at Atherfield.

Reptiles. The toe-bone of a very large *Iguanodon*, found under the cliffs of the Wealden strata on the shore of Sandown Bay,—and fragments of other bones, probably of the same animal, found near Brook Point?, have been described by Dr. Buckland, Geol. Trans. 2nd Series, vol. iii. p. 421.

Portions of the teeth of another Saurian, probably a *Crocodile*, have also been found at Sandown Bay.

Plants. Impressions of the leaves of a species of Fern: in the Wealden sand-rock: at Sandown Bay, and on the east of Barnes's Chine.

Dorsetshire.

(103.) *Isle of Purbeck.*—The principal additions which I have to make, to what Mr. Webster has published on the Isle of Purbeck*, are the distinction of the ferruginous sands below the chalk, which contain marine fossils, from the representative of the Hastings sands; and the indication of a stratum between the Portland stone and the Kimmeridge clay, which I propose to distinguish by the name of the *Portland sand.*

The section, Pl. X. a. No. 8. represents the coast on the east of the Isle of Purbeck, from the chalk at Ballard Down to Durlstone Head; and No. 9. a section near the middle of the peninsula, from the Chalk to the shore of Kimmeridge-bay, of part of which Plate X. b. fig. 6. is an enlarged illustration. In the coast section on the east of Purbeck the whole series from the chalk down to the Portland stone is disclosed†: the Upper green-sand, Gault,

* Letters to Sir H. Englefield; and Geol. Trans. 2nd Series, vol. ii. p. 37—41.

† A beautiful view of this section of the Isle of Purbeck is visible with a telescope, from the heights on the west of the Isle of Wight; and reciprocally, the transverse section of the latter

Lower green-sand, and Weald clay, in strata highly inclined, occurring in a nook or recess called Punfield, at the southern foot of Ballard Hill; and the Hastings sands, occupying the whole of the long range of cliffs thence to the town of Swanage; the section of which is so distinct, that with sufficient labour all the details can be made out. The strata correspond, however, precisely with what I have mentioned in the preceding accounts of the Isle of Wight and of the coast near Hastings*, and, as at those places, consist of sand and sand-rock, including concretions of calcareous grit, and alternating with a very large proportion of reddish and greenish cohesive sandy clay. Detached portions of lignite are frequent also throughout the series here. Fragments of the trunks of silicified coniferous trees have been found in dark brown masses; and detached bones of the Iguanodon sometimes occur loose on the shore beneath the cliffs near the town of Swanage†.

The Hastings sands can be traced entirely across the peninsula to Worbarrow Bay, in a range of heights passing through Godlingston, south of Westwood, Steeple, North Egleston, and Tineham: but the subdivisions between the sands and the chalk become indistinct on the west of Punfield; a slight difference only in the hue of the vegetation on the surface indicating in some places the presence of the Weald clay. The junction of the sands with the Purbeck strata is concealed, at Swanage, under the level tract which separates the sand cliffs from the hill above the town: and the only place among the numerous sections westward, in which the connexion between the Hastings and the Purbeck strata is visible, is on the south side of Worbarrow Bay. At the time of my examination, the appearances there were not distinct, but I shall here insert what I observed, as these beds are supposed to represent the strata on the north-west of Battle, which have been considered as the lowest in Sussex.

island forms a very striking object from the hill above the town of Swanage. Views thus seen from a sufficient distance have all the abstract clearness of a geological outline; while the minutest features are preserved without any departure from the true proportion of height to horizontal distance.

* For this reason I have thought it unnecessary to insert here the list of these strata to which I have referred above, (79.). The spaces which the several formations occupy, measured along the foot of the cliff, are thus: Upper green-sand, about 250 paces; Gault, 200; Lower green-sand, 240?; Weald-clay, 46?; Hastings sands, 3,500;—Total distance from the chalk to the bottom of the sands, about 4,250 paces. A flat of about 200 paces intervenes between the sand cliffs and the rise of the Purbeck strata. Compare these spaces with those at Man-of-war Cove, hereafter (110.).

† See Dr. Buckland's paper, Geol. Trans. 2nd Series, vol. iii. p. 421.

Beds on the confines of the Hastings sand and the Purbeck strata, at Worbarrow Bay.*

	Paces.
Grey sand, occupying on the shore	8
Yellowish sand.....	5
A space concealed at top; where visible the beds consist of grey clay, bituminous or carboniferous, which includes at the bottom concretions of quartzose grit, and contains Cyclades.....	9
A group including beds of stone composed of small Paludinæ, in a cement containing much green matter:—the "marble" and "marble-rag" of the Swanage quarry-men	16
Brown and grey clay, alternating with bluish grit, and thin beds of stone ....About	25
Clay and limestone, including the "Leaning vein" of the quarries on the east of Purbeck. [*Quæ.* the "Lane-end Vein" of Mr. Webster?]	?

Here the ground rises into the prominence called Worbarrow Knob; and the back on top of a very extensive mass of stone is waved, like the ripple-mark on the sea-shore. In the little cove between the "knob" and Gad Cliff, a thickness of about 50 feet consists of clay, alternating with beds of limestone very much contorted.

(104.) *Purbeck strata.*—The ridge of the Purbeck and Portland strata runs nearly from east to west, entirely across the peninsula; but the dip is not uniform, and the strata form a curve, or a portion of a dome-like prominence, of which the highest part is between Acton, St. Alban's Head, and the heights above Kimmeridge, and thence to Tineham Hat; the culminating point being about Swyre Head, which seems to be about 700 feet above the sea,—nearly on a level with the chalk down at the western extremity of Purbeck Hill, and perhaps 100 feet higher than the summit of Ballard Down†.

The whole of the Purbeck series is exposed in the ruinous cliffs of Durlstone Bay, where the strata have been enumerated in detail by Mr. Webster‡. At the upper part they consist of compact limestone, alternating with clay, and abounding in freshwater shells, especially of the genus Cyclas: but including also a thick bed called "cinder" by the quarry-men, which is almost entirely composed of oyster-shells. At the lower part, the formation consists principally of fissile limestone, the junction of which with the Portland strata exhibits some very remarkable appearances.

All the stone which is quarried at present, occurs in the upper part of the series; and from Mr. Webster's list it appears that in a thickness of about 125 feet, 55 consist of beds of useful stone; 12 feet of the "cinder" composed of oyster-shells; and the remaining 58 of slaty clay, and thin beds of unprofitable stone. I was informed that about 150 feet more, of what the work-

* This is the spelling of the Ordnance Map, and the word is so pronounced in the country. It is sometimes printed *War*-borrow, and by Mr. Webster, *Worth*-barrow.

† The top of the Down between Acton and Bottom, (about the place of the final *s* in "*Downshay's Farm*", in the Ordnance Map), is much higher than St. Alban's Head, and not much below Swyre Head. It seems to be nearly level with Encombe Head (Hound's-Tout), and the east end of Ballard Down.

‡ Geol. Trans. 2nd Series, vol. ii. pp. 38, 39.

men call "rubbish" and "slate", intervene between the lowest of the courses (or "veins") of good stone, and the top of the Portland formation; so that the total thickness of the Purbeck formation here is about 275 feet.

	Ft.	In.	Ft.	In.
Workable stone, and "rubbish"	99	0		
"Cinder"	12	0	124	8
Workable stone, and "rubbish"	13	8		
"Rubbish" and "slate"			150	0
Total			274	8

The high ground between Peverell Point and Durlstone Head is divided by a depression or ravine, on the north of which, in addition to the flexures and contortions seen in all the sections, and well represented in Mr. Webster's plates, the strata are traversed by fissures, produced by upheaving, or subsidence, or both. The effect of these disturbances can be traced by means of the "cinder" bed; disjointed portions of which are still visible, inclined at different angles, in three or four successive falls, the first throwing down that bed more than 100 feet, and others 40, 15, and 3 feet. The fissures which separate the disjointed masses are widest at the top, and are filled with fragments of the dislocated strata. The place where these derangements occur is called "the Gulley": on the south of it the strata are much less disturbed, and the "cinder" can be traced almost continuously in its proper situation, till it disappears near the face of the hill, not far from Durlstone Head.

The groups at the top of the formation called the "Marble" and the "Marble rag", consist for the greater part of small Paludinæ, cemented by carbonate of lime with a very large proportion of green matter. These beds are exposed on the shore at Peverell Point*, and were quarried many years ago at Langton, from which place it is said the pillars in the interior of Salisbury Cathedral were obtained. Another stratum, also containing a large quantity of green matter, but of a conglomerated or coarse sandy texture, is found at the top of the formation in some of the sections westward,—as near Worbarrow Knob, and on the east of Lulworth Cove. It includes a large and thick species of Unio; the shell, as Mr. Webster has remarked, being so abundant as to constitute a very large proportion of the whole mass.

A characteristic of the upper part of the Purbeck series, both on the coast and in the interior, is the occurrence of seams of fibrous carbonate of lime, frequently more than two inches thick, and either detached within the beds of clay, or adhering to the limestone beds, like the thinner crusts attached to the limestone of the Weald clay.

The bivalves, principally Cyclades, of which a great part of the Purbeck stone is composed, are not less numerous, and commonly much more distinct, in the slaty clay of the "rubbish" between them; which cannot be distinguished from the clay with Cyclades ("Shab") of the limestone pits on the north-west of Battle in Sussex. The "Slate", a coarsely fissile limestone at the lowest

* A very remarkable appearance, which I am at a loss to explain, was observed by Mr. Babbage and myself in 1824, on the back, or top of the Purbeck strata, at that time exposed on the shore between the town of Swanage and Peverell Point. The surface there, which dipped at an angle of 7° or 8° towards the north, was depressed in some places into nearly circular pits or cavities, from 4 to 7 feet in diameter, and about a foot deep in the middle,—as if the beds had been forced in by a violent blow; the depressed surface being divided by irregular but nearly concentric cracks, which were filled with white sparry carbonate of lime. Three of these depressions were visible; two of them about 6 feet apart, one of which was $7\frac{1}{2}$ feet, the other about $4\frac{1}{2}$ in diameter at the outer edge. A third, about 10 paces to the west of these, was of smaller dimensions.

part of the Purbeck series, was formerly much quarried for roofing, in the hill above Tillywhim, and near the south coast of the peninsula: and there, as well as in the corresponding beds of Portland and the north of Weymouth, I have found in it casts in calcareous spar of one or more species of Cypris.

(105.) *Portland Stone.*—This formation first appears upon the coast beneath the Purbeck strata at Durlstone Head, and rises slowly in the rocky cliffs on the west of Tillywhim to a point about midway between Winspit and St. Alban's Head, where it is succeeded by the Portland sand. The stony strata there retire as they rise from the shore, and occupy the margin of an irregular space thence to Gad Cliff, where they return to the coast and sink under the sea: so that between the extreme points of Durlstone Head and Gad Cliff (or rather Worbarrow Knob, a rocky hummock on the west of that place), a real curvature combined with the general inclination of the strata towards the north, which is in some places very rapid, has caused an extensive disclosure of the lower beds, excellent sections of which are visible on the west of St. Alban's Head. The component strata of the Portland stone in Purbeck, agree with those of the Isle of Portland, which have been described by Mr. Webster.

(106.) *Portland Sand.*—I propose to give this name to a group of strata which holds the place of that mentioned by Mr. Conybeare as occurring beneath the equivalent of the Portland stone at Shotover Hill in Oxfordshire, and in Bucks; and which in the interior contains a large proportion of sand, including green particles, ascertained by Dr. Turner to be of the same composition with those of the green sands beneath the chalk*. I have found a similar group abounding in green matter, and containing, as at Shotover, very large concretions of grit, in a corresponding place in the lower Boulonnois†, where a great part of the formation consists of sand. But on the Dorsetshire coast, and I believe, in the Vale of Wardour also, the beds are generally of a dark grey colour, more coherent, less sandy, and the calcareous matter which they contain, is more uniformly diffused‡. The group is certainly of sufficient importance to require a separate name, and that of *Portland sand,* while it expresses the more usual character, indicates also its intimate connexion with the Portland stone. On the other hand, it graduates into the Kimmeridge clay beneath; and its position seems to be

* See above, (10.) note §. † Geol. Soc. Proceedings, vol. i. pp. 9 and 27.

‡ On the west of Upway, however, near the coast of Dorsetshire, nearly half the substance of this stratum is made up of grains of green earth; and along the whole line of the formation in that quarter, the prevailing character is that of siliceous sand and green earth.—See Dr. Buckland's and Mr. De la Beche's Memoir, in the preceding part of this volume: p. 20, and note.

analogous to that of the sand and subcalcareous grit which occur between the Oxford oolite and Oxford clay,—the inferior oolite and the lias clay: ?? The whole mass of strata deposited in the first instance, having been in all these cases, sand and mud; the upper part of which abounding more in calcareous matter, was subsequently converted into stone, and the lower more or less concreted into nodular masses of calciferous grit, in proportion to the quantity of carbonate of lime diffused through it.

In the Isle of Purbeck, the *Portland sand* first rises above the sea about midway between Winspit and the point of St. Alban's Head, and is disclosed by denudation on the north of that remarkable promontory, in a ravine called Pier Bottom, near which place the Kimmeridge clay appears to rise on the shore. A good section of the sand is visible at Emmet's Hill, a ridge capped with Portland stone, between Pier Bottom and Chapman's Pool; and the group may be traced thence, beneath a capping of stone, all round the inflections of the high ground from Bottom Farm, by the prominences called Encombe Point (or Hound's Tout), and Swyre Head, through Kimmeridge, to Gad Cliff, where it declines along with the stone and sinks again under the sea. Its relative place and its effect in modifying the surface, are well seen in the amphitheatre of high ground which nearly encircles Kimmeridge Bay; of part of which Pl. X. a. No. 9, and X. b. fig. 6, are illustrations: the summits all around consisting of Portland stone, and the rapid grass-covered slope beneath of this sand, resting upon a tract comparatively flat and uniform, which is occupied by the clay of Kimmeridge. The sand again makes its appearance on the coast west of Purbeck, in a small portion distinguishable by its bluish grey colour, beneath the rocky cliffs called Horsewalls, which form the most prominent part of the shore between Lulworth and Durdle Cove. In the complex and disturbed tract on the north and west of Whitenore, the Portland sand is found wherever the superior strata rise high enough to disclose it; and in the Isle of Portland it everywhere accompanies the stone, and has the same characters as on the coast of Purbeck.

The following is a List of the strata at *Emmet's Hill*, immediately on the north of St. Alban's Head:—Pl. X. b. figs. 5 and 6.

	Feet.
1. *Portland stone*, with layers of flint near the bottom, forming a shattered and inaccessible precipice at the top of the cliff ..... 30 to 40 feet	
2. *Portland sand.* Soft stone, or marly coherent sand, with a rugged external surface of a yellowish grey or brownish colour; but in the recent fracture, of a dark bluish or greenish grey. It includes concretions of firmer consistence. In a bed of stone of the same description at the cross-roads above Kimmeridge Farm, which seems to belong to the same place in the series, *Trigonia clavellata*, *Ammonites giganteus*, and other fossils are found	25 to 30
3. Bluish grey, inclining to green, sandy clay and marl, including ranges of concretions approaching to stone: the whole effervescing with acids. The more stony portions acquire by exposure a yellowish brown tinge, and are in some places coated with a crust of white pulverulent carbonate of lime. A bed of this group dug for building near Bottom Farm, consists of bluish grey sandy stone, but slightly effervescent, and is streaked or mottled with portions of a darker hue. In some other places the strata are divided by fissures into nearly vertical flakes, two and three feet in thickness, and include occasionally nodules of much more compact texture.....	about 60

	Feet.
4. A rugged platform at the foot of the cliff above described, is covered with debris, and partially clothed with shrubs and vegetation. The beds appear to be:—	
a. Soft, dark bluish grey, effervescent sand-rock, or indurated marl, including a band of firmer consistence, which contains casts of *Panopæa depressa* and other bivalves.	40 to 50
b. Brownish marly sand-rock, softer than *a.*	
c. A firmer stratum, including, about 20 feet from the bottom, large subglobular, but nearly continuous concretions of greater firmness, which also contain casts of *Panopæa depressa* and other fossils. [These concretional masses, not improbably represent the great nodules of Shotover Hill in Oxfordshire.]	
Total estimated thickness of the sand.....	120 to 140

Springs break out at the bottom of this group, where the Kimmeridge clay might be expected. The total height from the top of the cliff may be between 250 and 280 feet.

(107.) *Kimmeridge clay.*—The clay which has obtained its name from the farm and bay of Kimmeridge, rises from beneath the beds last mentioned,—on the east, near the point or southern prominence of St. Alban's Head, and on the west, immediately under the lofty precipices of Gad Cliff. It occupies, apparently, the whole of the low undulating tract which intervenes between these extreme points; and is capped, about the middle, by the projecting mass of Portland stone and sand which forms the summit of Swyre Head. The bituminous strata which characterize this formation are seen with greater distinctness on the shore of Kimmeridge Bay, as the coarse sand, grit, and limestone found between them and the Oxford oolite on the north-east of Weymouth, do not come up to the surface in the peninsula of Purbeck. The little promontory of Hen Cliff may be considered as the centre of an almost semi-circular space, which is continued in a narrow slip or platform, along the shore to Pier Bottom: Plate X. b. fig. 6.

The strata on the shore at Kimmeridge Bay form a low dome-shaped prominence, the culminating point of which is at some distance from the ridge of the Isle of Purbeck. At Broadbench, where they are very well displayed, they rise with a very slight inclination from the south; and rise also from beneath Gad Cliff on the west; but at Hen Cliff the dip is towards the south-east, conformably to the general disposition of the strata beneath St. Alban's, and thence to Durlstone Head; while it is obvious that under the main ridge of the peninsula they must dip to the north, along with Portland and Purbeck strata. The rise of the beds from the sea, where the shore is cut into by the circular erosion at Kimmeridge, has produced an apparent curve in the cliffs around the bay; so that the strata seem to rise from the sea near Broadbench, and to decline again as the line of the coast returns toward the south in approaching Hen Cliff. The natural sections hereabouts are very distinct; and a considerable surface also of some of the strata is exposed upon the shore, consisting apparently of the lowest beds in the Isle of Purbeck. The coast at Kimmeridge Bay is probably not less than 400 feet below the bottom of the Portland stone; and if 100 feet of that interval be assigned to the Portland sand, it will follow that

about 300 feet of the bituminous Kimmeridge clay are disclosed on the coast of Purbeck; which probably, is not far from the total thickness of the formation.

The beds here consist in general of bituminous fissile clay in a large proportion, alternating with thin courses of brown subcalcareous stone, or bituminous limestone. The clay in some cases contains so much bituminous matter, as to be used for fuel under the name of "coal*"; in others it contains a large proportion of carbonate of lime, alternating with the laminæ of the clay. To these more calcareous and whiter beds the name of "White Lias" is given in the neighbourhood.

The connexion of the Kimmeridge clay with the Portland sand and stone is visible, though the section is in some points inaccessible, at a place between Gad Cliff and the commencement of the lower cliffs of the bay, where the following was the order:—

1. Dark sandy marl (Portland sand) about 100 feet. A specimen taken here about 100 feet below the Portland stone, consists of light grey, soft, calcareous matter, including minute green particles in very large proportion; the whole very much resembling some portions of the Upper, and of the middle strata of the Lower green-sand.

2. A series of beds about 30 feet in thickness, composed of shale, in part so bituminous as to serve the purposes of fuel; in other places passing into a very bituminous soft fissile limestone ("White lias") of a light brown or grey colour, which on decomposing becomes almost white. The dark surfaces of the fissile beds are spotted with numerous light grey specks, probably the remains of organized bodies.

Another form in which calcareous stone alternates with the bituminous shale above mentioned, is that of a dark brown stone,—sometimes of the consistence of indurated marl, effervescing freely, sometimes acquiring a flat conchoidal fracture and greater hardness, and but slightly effervescent.

The strata around Kimmeridge Bay, which seem to belong to a lower part of the series than the second group above mentioned, include a remarkable bed of brown, bituminous, and somewhat gritty limestone, about two feet thick, which is divisible into rhomboidal fragments. This is succeeded by a considerable thickness of shale, less bituminous than the "coal"; which includes with other fossils, great numbers of *Ammonites biplex* much compressed, and alternates with thin beds of the limestone. At Hen Cliff three or four such beds occur in the shale. One of the same character is conspicuous in the arch or curve of the cliff at Kimmeridge Bay, and another about 30 feet below, seems to be the lowest stratum of the Isle of Purbeck.

The Kimmeridge clay, sinks into the sea at Gad Cliff, and does not again appear till after an interval of seven or eight miles, where a very good section is visible in Ringstead Bay on the west of Whitenore. The beds which occupy the shore thence to Weymouth Bay form the transition from this clay into the Oxford oolite; and as a full account of them will be given by Dr. Buckland and Mr. De la Beche†, I shall only mention here that the

* It burns with a bright flame, emitting a very disagreeable smell, and leaves a grey, light, and spongy cinder.

† The country around Weymouth had been previously illustrated by a paper of Professor Sedgwick, in the Annals of Philosophy for 1826, vol. xi. p. 339, &c.; where its resemblance to the cliffs near Scarborough was pointed out, and the relations of the beds between the Portland strata and the Oxford oolite, in different places, explained. The Memoir of Dr. Buckland

whole of this series, including both the bituminous strata of Kimmeridge, and the more complex group beneath, is fully developed in the Lower Boulonnois, of which I have given an account in another paper read before this Society*; and that the coast of Yorkshire near Scarborough is composed of similar strata†.

(108.) On a general view from the heights in Purbeck or Portland, of the great bay or excavation of the coast, of which the Isle of Purbeck forms the east wing, and that of Portland the western promontory, it is natural to suppose that the strata in both places are the remaining portions of a wide plane, which at one time passed continuously through both places, and formed the reflected portion of that which rises from beneath the chalk and runs in a nearly uniform direction from Ballard Hill to the heights near Lulworth Cove. This ridge, if continued, would pass through Weymouth: but the chalk is suddenly interrupted at Whitenore Cliff, and its main outcrop on the west of that place, being directed towards a point about 15° or 16° north of west, makes an angle of about 20° with its previous range through the Isle of Purbeck. On a close examination, this change is found to be attended with some very remarkable circumstances; the coast on the north and west of Whitenore having been the scene of great disturbance, by which a very complex series of faults has been produced. The general disposition of the strata, however, is still that of a saddle; the northern side of which dips to the east of north, while the beds in the Isle of Portland, (the only remaining portion of the slope on the south side,) decline towards a point about 48° east of south‡. The upper beds of Portland are therefore but a part of the mantle-shaped covering which once enveloped the lower strata both in Portland and in the intermediate space from thence to Kimmeridge Bay, where indications of the mantle-shaped arrangement are still visible; the strata on the east of the bay sinking into the sea between Tillywhim and Durlstone Head, very much in the same manner as they do at the Bill of

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and Mr. De la Beche, so often referred to in the text, has been printed in the beginning of the present volume of the Geological Transactions.

* Proceedings, vol. i. p. 6.

† Sedgwick; Ann. of Phil. 1826. J. Phillips; Geology of Yorkshire, 4to, 1829.

‡ The *strike* in Portland is well determined by the position of the two points on the opposite side of the island, where the beds beneath the stone rise from the sea. These are,—on the west coast, a spot almost due west of the words "Hr. Light" in the Ordnance Map; and, on the east coast, the place where the shore is cut by a line passing through the letter c in "Church-hope," and the bottom of the letter E in the word "ISLE". The line joining these opposite points, makes an angle of about 48° with the meridian; the dip being consequently directed to about 48° east of south. See the Map, Plate VIII.

Portland. The structure in this case is, in fact, analogous to that of the Isle of Wight; except that the top of the curve has in that place been carried away, and that what remains of the upper strata on the south of the island is much less inclined.

(109.) *Coast west of Purbeck.*—The sections west of the Isle of Purbeck, as far as Whitenore on the coast of Dorsetshire, have been generally described and represented by Mr. Webster with his usual clearness *, but have not yet been examined in detail. The Purbeck strata especially are disclosed there under a great variety of aspects, no fewer than nine sections of the beds between the chalk and Portland stone being visible, on the shore of the small bays by which the coast is indented, within the short space of five miles †. One of the most remarkable circumstances in the structure of this part of the coast, is the rapid convergence of the strata in proceeding westward from the Isle of Wight; the total distance from the top of the greensand to the beginning of the Portland stone, which, between Ballard Downs and Durlstone Head is about two miles and a half, being reduced to about 150 paces at Durdle Cove. The sectional sketches Pl. X. a. Nos. 8. to 10′, which are drawn to the same scale, exhibit the proportion of this reduction; and Pl. X. b. figs. 7. and 8., show on a much larger scale, the detail of the beds in the east side of Lulworth Cove, and on the east of the isthmus connecting the ridge of Portland stone with the chalk, at Man-of-War and Durdle Coves; beyond which some detached vertical masses, standing out in the sea like walls, and successively coming nearer to the main cliff, are the last indications of the beds below the chalk upon this part of the coast.

In these western sections of the groups immediately below the chalk it is impossible to recognise all the subdivisions of the coast of Kent, and the adjoining counties; the separation between the upper and lower green-sands having in a great measure disappeared, and the latter being greatly reduced in thickness, or wholly united with the upper sands. In the Wealden, likewise, the clay can scarcely be separated from the strata representing the Hastings-sands, which occupy a considerable space; and here, as in the Isle of Wight, the proportion of red and variegated sandy clay to the ferruginous sands is very great, one distinct group of such clay being observ-

* Letters, &c., pp. 185-6, 193-7.

† These sections are: 1. *Worbarrow Bay.* 2. *Mewp Cove*, not named in the Ordnance Map. 3. *Bacon Hall*, a nook on the west of Mewp. 4. and 5. *Lulworth Cove*, east and west sides; Pl. X. a. No. 10.; and X. b. fig. 7. 6. *Stare Cove.* 7. West of *Horse-walls.* 8. *Man-of-War Cove*; Pl. X. a. No. 10′., and Pl. X. b. fig. 8. 9. *Durdle Cove.* The coast hereabouts being difficult of access, and the adjacent country thinly inhabited, I believe that the best stations for a geologist who wishes to examine it with ease, would be Swanage, for the eastern part of the Isle of Purbeck; and East Lulworth, for the coast westward. A good boat should be taken in calm weather, at Lulworth Cove or at Worbarrow, to view the cliffs from the sea.

able at the top and another at the bottom of the sands. The curves and contortions of the limestone beds in the Purbeck strata, where they alternate with clay, are strongly contrasted with the parallelism and regularity of the more uniform parts of the series, both in the sands above, and the Purbeck and Portland formations below; the difference being probably ascribable (as Mr. Conybeare, I believe, has remarked,) to the effect of lateral pressure, upon a mass consisting of folia which differ so much in their power of resisting flexure and compression, as the limestone and the clay.

Lulworth Cove.—The relative space occupied by the different groups below the chalk, on the east side of this Cove, is as follows: (See Pl. X.a. No. 10.; and X.b. fig. 7.)

	Ft. In.
1. *Upper Green-sand*, including large concretions of chert	76 0
2. *Blue Clay* (*Gault*), occupying a depression, in part covered with grass	66 0
3. *Wealden.* Clay and sand:—	Feet.
a. Reddish sand and clay	122
b. Sand of various shades, yellowish and brown: about the middle are beds of coarse conglomerate, consisting of fragments of translucent quartz and of blackish flint. [A coating of diluvial gravel extends from the chalk to about the middle of this space, where the cliff is about 40 feet high.]	281
c. Reddish sand and clay. [The cliff is here 10 or 12 feet lower.]	80
d. Dark-brown sand, including fragments of lignite and of fossil wood. [Large Unios and a small Paludina (*elongata*?) are found near this place.]	4
e. Grey and whitish sand 15 0 Greenish clay and sand. [Cliff about 30 feet high.] 26 0	41
f. A band of red clay and of dark-brownish matter	?
g. Yellowish sand	
h. Dark carbonaceous sand	
i. Variegated sand and clay, greenish and reddish. [A depression here in the outline of the cliff. At the lower part beds of compact grey lime- and clay. Surface in part concealed and covered with grass.]	66
Total, about	600 0
4. *Purbeck strata*: estimated at 150 yards; cliff about 80 feet high. [Distinct ledges of coarse sand-rock, including much green matter and a thick species of Unio, are quarried near the top of the formation. On the shore were fragments of beds of fibrous carbonate of lime, 7 to 8 inches thick]	450 0
5. *Portland-stone* (estimated at 80 yards)	240 0

The *Upper Green-sand* is very distinct in this section. The place of the *Gault* is indicated by a slight depression, which is continued in the grassy hills on the east of the Cove. The *Lower Green-sand* may, possibly, be included in the general mass of sand, 3. *a.*; but the *Weald clay* is not distinguishable. Below the mass of yellowish and ferruginous sands, 3. *b.*, is a considerable extent of variegated clays, comprising beds much charged with carbonaceous matter; the whole clearly referrible to the *Hastings sands.* The transition thence to the *Purbeck strata* is not distinctly seen; but some of the beds, 3. *i.*, of grey uniform limestone, alternating with clay, near the junction, resemble those of the "lime-works" on the north-west of Battle, which are supposed to be the lowest members of the Hastings series. The top of the *Purbeck* on the east of the Cove contains very numerous Unios in coarse green sand-rock: and on the west side a bed of greenish slaty stone, in the upper part of the series, consists of oolitic particles, and contains Cypris. Near the junction of the Purbeck with the *Portland stone*, the site of the "Dirt-bed", which in the Isle of Portland contains silicified trees and Cycadeæ, is very distinctly seen.

Man-of-War Cove, Pl. X. a. No. 10′.; and X. b. fig. 8.—In the isthmus here, which connects with the main land a wide peninsular mass of Portland stone rising towards the south, many of the beds are inclined backwards, and lean towards the chalk hills. A coating of reddish gravel, from 3 to 6 feet thick, extends to some distance from the chalk along the top of the isthmus, and is shown by the dotted line in fig. 8. The following are the strata at this place:

	Paces.
1. *Chalk.*	
2. *Green-sand*	35
3. *Wealden-clay and Sands.*	
a. Dark clay, much mixed with sand; and including a mass of ferruginous sand-rock, 4 to 6 feet thick: seems to represent the *Weald clay*	7
b. Light grey, and white sand	7
c. Red clay, nearly vertical; but inclining a little towards the chalk	10
d. Grey, and brownish sand, including at top a conspicuous bed, of dark hue, which contains much lignite in large pieces. [The breadth of the isthmus here, at the bottom, is about 150 paces from west to east; at top about 40 paces.]	40
e. Dark red and variegated clay. A considerable depression here in the outline of the cliff	10
Total, about	74
4. *Purbeck strata.* Upper calcareous beds much distorted. About the middle a bed of oysters is conspicuous, which, as it rises, is divided like a Y, and one of the portions reflected back towards the chalk. Estimated thickness (probably less than the true)	30
5. *Portland stone* (estimated)	80—90

(110.) *Isle of Portland* *.—The coast of Dorsetshire, from the promontory of Whitenore to Lyme Regis, forms the subject of a memoir by Dr. Buckland and Mr. De la Beche, which is printed at the commencement of the present volume: I shall not, therefore, give any general description of it; but having been favoured with a perusal of that valuable paper, I find it necessary to mention some details respecting the appearances observable near the junction of the Purbeck and the Portland formations, with a view to a comparison of this part of the series in the interior, with that of the coast in England, and in the Boulonnois.

Mr. Webster, in his account of the strata above the Portland stone†, has described a remarkable bed, called by the quarry-men the "Dirt" or "Black "dirt", which he found to contain portions of the trunks of silicified trees; one of which he himself saw standing upright, and divided at the lower part, "so as to give the idea of roots". He states that these trunks were not found in any other part of the series; but not having seen any fossils in the beds above the Portland stone, he expresses himself with caution as to the place of the boundary between the Purbeck strata and the oolitic group beneath

* The substance of this and the following sections, to (116.) inclusive, was read before the Geological Society on the 13th of May, 1835; and is inserted here by permission of the President and Council.

† Geol. Trans., 2nd Series, vol. ii. p. 39, &c.; read Nov. 1824.

it; intimating, however, that it will probably be found at the top of the chert or flint in the upper part of the oolite. Some years afterwards Dr. Buckland described specimens of a new family of fossil plants from the "Dirt-bed" above mentioned; to which, at the suggestion of Mr. Brown, he gave the name of Cycadeoideæ*, but which M. Adolphe Brongniart, adopting a different system of nomenclature, soon after formed into a genus which he called Mantellia†. Dr. Buckland was subsequently led to infer that the "Dirt-bed" was actually the soil in which both the silicified trees and the Cycadeoideæ had grown: and in a paper read before the Society in 1830‡, now published in this volume, he and Mr. De la Beche have stated several facts respecting that remarkable bed; adding in a note§ that Professor Henslow had ascertained the existence of two other beds of dirt (or of clay with carbonaceous matter) below it; one of them about seven feet beneath, the other about two feet still lower down.

On visiting the Isle of Portland last summer, with a knowledge of these facts, I found that the clay, or "dirt", below the *Cap*, (the upper apparently of the two additional clays described by Professor Henslow,) itself contains Cycadeæ, in an upright position, and to all appearance in the places where they had grown; and I obtained also some new evidence respecting the character of the beds immediately above.

(111.) The following are a sketch and enumeration of the strata exposed at the time of my examination, in the quarries about the middle of the island, and westward of that point; which I was enabled to revise during a second visit to Portland, when I had the satisfaction of being accompanied by Mr. Brown.

The whole mass of the strata which now form the Isle of Portland must have been subjected to great disturbance long before the surface acquired its present configuration; by which the vertical rifts, from a few inches to some feet wide, were formed, which are now observable in the face of the quarries, passing indiscriminately through both the Purbeck and Portland strata, and having in many instances produced displacement in the separated portions: and this at such distances from the present coast of the island, as to prove that no recent disturbance or subsidence of the sea-cliffs has had any share in producing them. Yet it is remarkable that the surface over these disjointed beds is now perfectly uniform; the inequalities occasioned by the sinking and fracture of the slaty Purbeck strata near the top having been completely filled up to a level by rubble and vegetable soil. In one place a fissure between two and three feet wide cuts down, almost vertically, through about thirty feet of stony strata,

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* Geol. Trans., 2nd Series, vol. ii. p. 395; read June, 1828.

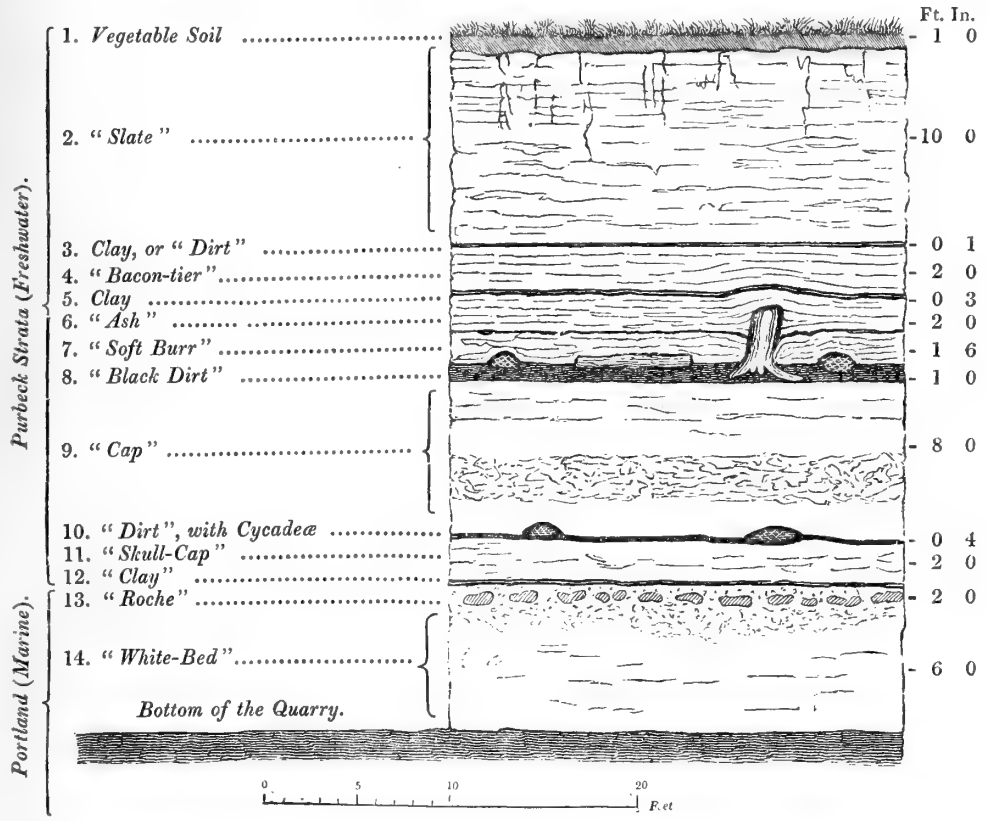
† *Prodrome d'une Histoire des Végétaux Fossiles*, 1828, pp. 92 and 96.

‡ Proceedings of the Geol. Soc., vol. i. p. 217. *et seq.*

§ Page 16. of the present volume.

and still retains its width at the bottom. The thin slaty beds of the Purbeck are in this instance disturbed and bent, downwards and towards the fissures, to some feet on both sides; but the soil above is perfectly level; and in some other cases, where two or more cracks are near each other, the intermediate masses are still more contorted and displaced. It will be shown hereafter that appearances of the same kind are observable in the Portland-stone quarries in Wiltshire, Oxfordshire, and Bucks.

Section of one of the Portland Quarries. 1834.



2. The "*Slate*" of the preceding section is nothing more than the coarsely fissile limestone which pervades the whole of the Purbeck formation, but at the lower part less frequently alternates with clay. Its thickness varies in different parts of the Isle of Portland, from about fifteen to less than six feet. In some places it includes small veins of rhombic carbonate of lime in minute crystals; but has commonly the general aspect and flat conchoidal fracture of freshwater limestone. On a close examination these beds are found to contain the remains of one or more species of Cypris*; and I saw a few traces of small Modiolæ, like those which abound in the corresponding strata in the Vale of Wardour and Buckinghamshire. The Cypris, in fact, is found in all the beds above the oolite (13. of the Sketch above); so that no doubt remains respecting the boundary between the Purbeck and the Portland formation below. Nothing can

* As, with few exceptions, casts only of the interior of the crusts are obtained here, it is difficult to determine the species of these fossils. Mr. Sowerby is disposed to refer most of them to a new species, *C. tuberculata*, Pl. XXI. fig. 4.; and a few perhaps to the *C. Valdensis*, Pl. XXI. fig. 1.; both of which abound in the corresponding part of the Purbeck formation in the interior.

be more remarkable than the immediate contact of these two groups; the upper consisting of freshwater limestone with few fossils; the lower distinctly oolitic, with fossils in great number and variety, and all of them marine*.

3. Besides the "*Black* Dirt" (No. 8.), or, as it is usually called by the quarry-men, "*the* Dirt", two or more thin courses of clay occur above the *Cap*: one (No. 3.), about two inches thick, between the *Bacon-ledge* and the *Slate*; another (No. 5.), about an inch in thickness, dividing the former from the *Ash*. The number, however, of these thin beds of clay varies in the different quarries; and, in general, it may be said that such alternations with the limestone are not unfrequent. They all bear the name of "Dirt", and are more or less mixed with fragments of stone and with carbonaceous matter; but contain commonly much more clay than either of the two beds hereafter mentioned, which include the remains of plants.

4. The *Bacon-tier* consists of calcareous slate alternating in some places with thin beds of sand. It is from 2 feet to $2\frac{1}{2}$ feet in thickness.

6. *The Ash* is a soft fissile limestone, like the last-mentioned bed, from which it is easily separated in working. In general it is from eighteen inches to two feet thick, and is closely connected with the *Soft Burr*, 7. When the incumbent beds are removed, it generally exhibits an uneven surface, with numerous bosses or prominences, enveloping the broken tops of the trunks, which stand upright in the dirt-bed below, as described by Dr. Buckland and Mr. De la Beche. Oblong depressions also are frequently observed on the surface of the *Ash*, called by the quarry-men "graves", the origin of which it is not easy to explain.

7. The *Burr of the Ash*, or *Soft Burr*, is between two and three feet thick. It has obviously been deposited around the lower part of the petrified trunks, and is always separated from them by a small space, at present occupied by the carbonaceous matter produced by the decomposition of part of the tree: and this is the case also where the *Ash* envelopes the top of the broken stumps. The junction of these two beds, around the trunks, is often attended with some very interesting appearances, for an account of which I refer to a note by Professor Henslow in the preceding part of this volume†.

8. The "*Dirt*", or "*Black Dirt*", in Portland is separated from the stone, both above and below, by well-defined surfaces; while some of the other beds of clay, or dirt, pass by gradation into, or adhere closely to, the stone which adjoins them. It is from twelve to eighteen inches thick, and differs from all the other beds alternating with the slaty limestone, in containing large worn fragments of stone‡, from three to nine inches in diameter, in such numbers that the whole deserves the name of coarse gravel. With these are mixed coarse carbonaceous matter and minuter fragments of stone; but seldom, in the Isle of Portland, any continuous or cohesive clay:—the carbonaceous matter arising, no doubt, from the remains of vegetables, and being most abundant immediately around the trunks and Cycadeæ, which this bed includes, or supports.

At Upway, on the north of Weymouth, the representative of the "Black Dirt" likewise contains petrified trees: but the pieces of stone which it includes are few and much smaller, and it approaches more nearly to the usual form of vegetable mould, or of clay. On the north-east of Weymouth its place can be distinctly recognised in the cliffs between Lulworth Cove and Wor-

* Compare what is here stated, with the account of the junction of the marine beds with the top of the Wealden, at Atherfield in the Isle of Wight (*supra*, p. 196, last lines).

† Pages 16. and 17.

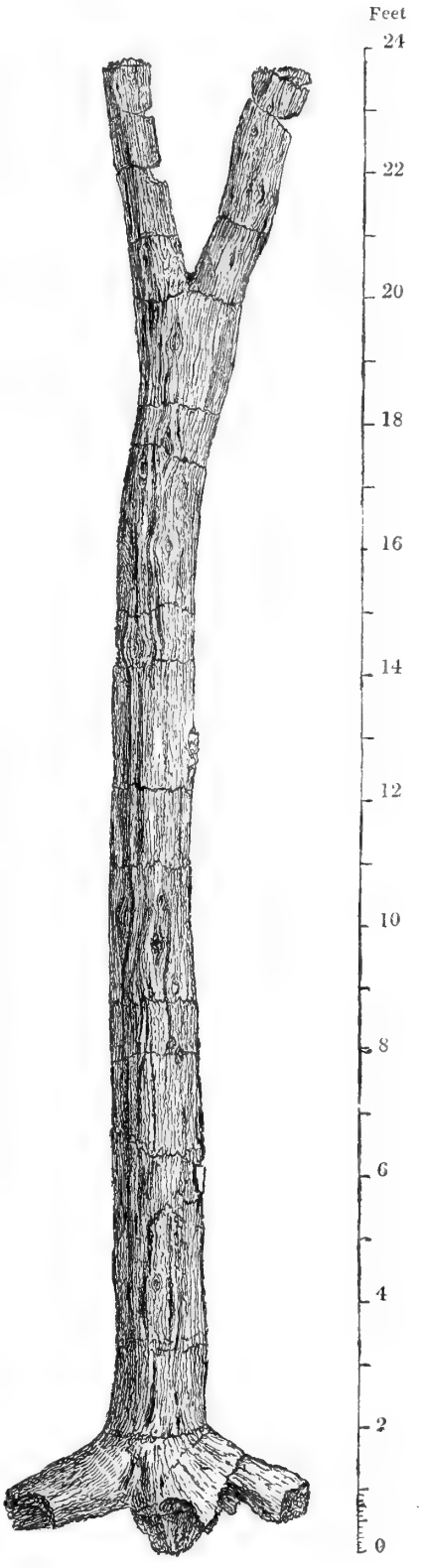
‡ In these fragments I could find no fossils; Mr. Webster considers them as belonging to the lower beds of the Portland stone.

barrow Bay; and in the Isle of Purbeck, beneath Worbarrow Knob. In the loftier cliffs at Gad Cliff it is not accessible; but among the fallen ruins on the shore were some portions of silicified trunks. Between Tillywhim and Durlstone Head a cavity can be perceived in some places, in the part of the cliff where this bed might be expected.

Petrified Trees.—The portion of the trees left standing above the dirt-bed in Portland, is frequently more than three feet in height: and one instance was mentioned to me in which six feet of a trunk stood thus in the upright position. I did not see any case in which the roots penetrated into the Cap below; but observed several fissures in the top of that bed, some of them coated with a crust of stalactitic carbonate of lime. In one instance a prolonged branch of the root had evidently been bent out of its course by meeting the Cap, and was continued horizontally along its surface for several inches: the quarrymen said that such cases were not uncommon, and that the roots sometimes ran along the top to a much greater distance, but never penetrated the Cap itself.

Some very fine specimens of the silicified trunks had been found not long before I saw them; one of which had been judiciously restored, by joining the fragments and placing the whole erect against the wall of a house. The total height from one extremity to the other was above $20\frac{1}{2}$ feet; the diameter of the stem where the roots went off, about $11\frac{1}{2}$ inches. The trunk was nearly straight and undivided for about 17 feet, and the branches slight in comparison with the main stem.

A still finer specimen, found, I believe, near the same place, in Dungeness Quarry, and at the same time with that just described, has been brought to London for sale; and I am enabled, through the favour of Mr. Freeman, in one of whose warehouses the specimen was deposited, to insert a representation of it, from a drawing made by Mr. Sowerby, after careful admeasurement, as it lay horizontally, the fragments which had been separated appearing to fit exactly. The total length, from the extremity of the roots to that of the branches, was about $23\frac{1}{2}$ feet, and to the bifurcation nearly 20 feet. The roots and undivided portion of the stem to the first crack, occupied about 2 feet. The situation of the other cracks, of which there are fourteen or fifteen, is expressed in the figure. The trunk is compressed throughout; the branch on the right, especially, having been much flattened near its extremity.



At 2 feet from the extremity of the root, the greatest diameter is $18\frac{3}{4}$ inches, the transverse diameter only $12\frac{1}{2}$; at 4 feet, the diameters are $16\frac{1}{2}$ and $11\frac{1}{4}$ inches; at 11 feet, $14\frac{3}{4}$ and $11\frac{1}{2}$; and at 18 feet, 15 and $9\frac{1}{2}$ inches. The right branch at its extremity, 11 and $4\frac{1}{2}$ inches.

The specimen here represented is much like that which is preserved in the Isle of Portland, in general aspect and proportion; but many of the stumps which I saw standing in the quarries were much larger. One that I measured,—of which 5 feet stood upright from the lowest point of the roots to the top of the broken trunk,—was 2 feet in one of its diameters, and 6 feet 9 inches in circumference. Another, 5 feet 10 inches in total height, was about 2 feet 10 inches in diameter, and 9 feet 4 inches round; and I was assured that others had been found of much greater thickness. All the larger trees that I saw were in the quarries on the north-west of the church; one of which afforded also the specimen represented in the wood-cut, with several large Cycadeæ. In many places I saw large branches lying prostrate, and partially immersed in the Dirt;—one of them, above 3 feet long, within 2 feet of another portion, about 10 feet in length, and in the same direction with it*.

From the evidence afforded by thin transparent slices, both of the transverse and longitudinal sections, which have been examined under the microscope† by Mr. Brown, the fossil trunks of Portland are found to possess the characters uniformly belonging to coniferous wood: but it must be observed that these characters are not absolutely confined to Coniferæ.

The *Cycadeæ* found in the "Black Dirt" are generally from 9 inches to a foot in diameter, and about 9 or 10 inches high. I myself saw but one specimen, which had been recently taken from its place, in this bed; and it was stated by the quarry-men that on the west of the main road from Chiselton to the church, they have been found, or noticed, only in the Dirt above the Cap; while on the east of the road, as I shall presently mention, they are certainly found below that bed. In the eastern quarries, indeed, the workmen, who had not seen them elsewhere, asserted that the Cycadeæ were never found above the Cap; but this I found afterwards to be incorrect. In both situations, they are much less common than the coniferous trunks.

9. The "*Cap*" is the thickest of all the strata above the Portland stone; the average thickness being about 8 feet, the extremes 6 and 9 feet; of which, in some cases, about 18 inches at the top are easily separable from the rest. When recently exposed, the whole of the remaining mass is continuous, and consists chiefly of uniform limestone of a light brownish or drab colour, with a flat conchoidal and splintery fracture; but it cannot be used for building, as, in the workman's phrase, "it will not *square*." About the middle and towards the lower part it is spongy, or cavernous, including tortuous cavities surrounded with botryoidal carbonate of lime; and it has

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* It would be desirable to ascertain the direction in which the prostrate stems lie, with respect to the meridian, and to the roots and portions of the trunk remaining upright, in order to determine whether they were overthrown by an uniform current of wind or water.

† One of the longitudinal slices examined by Mr. Brown was broken from the extremity of the left branch of the tree represented in the annexed wood-cut.

The process by which these slices are prepared for the microscope has recently been carried to great perfection by Mr. Nicol of Edinburgh. It consists in attaching a thin polished slice of the fossil, separated by the ordinary method, to a piece of plate glass, by means of a uniform cement; and then grinding it down as far as possible on the lapidary's wheel. In this way transparent slices have been obtained, which exhibit the internal structure of fossil wood with beautiful distinctness, and show the extreme delicacy with which the original vegetable structure has been preserved during the petrifactive process. Two papers by Mr. Nicol on the structure of the recent and fossil Coniferæ are published in the Edinburgh Philosophical Journal, vol. xvi. 1834, pp. 137 and 310; and a third in the Report of the Fourth Meeting of the British Association for the Advancement of Science, 1834, p. 160.

altogether a very strong resemblance to the *Travertine* of Italy. The top is sometimes penetrated by conical and nearly vertical cavities, encrusted with a yellowish stalagmitic coating. In the Isle of Portland it is compact and continuous at the bottom; but in other places the lower part, and in some cases the whole, is resolved by decomposition into slaty strata.

At Upway, on the north of Weymouth, the lower portion of the Cap consists of a series of thin beds of limestone alternating with very thin courses of clay. In Portland, even where most compact, it contains a few casts of a small species of Cypris; and these seem to be more frequent (perhaps because more easily detected) in the more fissile representatives of the bed at Upway and Bacon-hall. In one or two instances I found in it obscure traces of small univalves like those of Garsington and Combe Wood near Wheatley in Oxfordshire.

In a nook or recess, called by the boatmen *Bacon-hall**, upon the coast about a mile east of Lulworth Cove, the section of this part of the series was as follows:

a. "*Black Dirt*" of Portland.

b. *Cap*, consisting of:

i. Slaty limestone, divided by dark lines of stratification; which at the lower part become more distinct, and at last take the form of ii.

ii. Dark grey indurated slaty clay; one bed of which is nearly 2 inches thick.—Beneath it is

iii. A thin flake of soft whitish limestone.

c. *Dirt.* An indurated bed, of a light brown colour, 4 to 5 inches thick; composed of argillaceous (and carbonaceous) matter, and including small fragments of stone.

d. (*Skull-cap?*) Limestone, somewhat botryoidal; the more compact portions having a flat conchoidal fracture; 2 to 6 inches thick.

e. *Portland stone*, abounding in the characteristic fossils, and including, about 6 feet from the top, a band of flint, in detached masses, about 4 inches thick.

10. "*Dirt*" *below the Cap.* Immediately below the Cap in the Portland quarries, and consequently separated from the "Black Dirt" by a thickness of about 8 feet, is another bed, also called "Dirt" by the quarry-men, from 2 to 6 inches thick, but more uniform in its texture than the former, resembling coarse silt or indurated loam, and containing in some places small fragments of stone, but never such large masses as the "Black Dirt". This lower bed deserves especial notice, from its affording specimens of Cycadeæ, in an upright position, and partially immersed in it, as if they had grown there. Of these I myself saw two in their original place at a quarry called "the Wheat-croft", on the east of the "Traveller's-rest"; one of them about six inches high, surrounded with the Cap, into the lower part of which it projected above the Dirt for about half its thickness, so that it was necessary to cut away the stone to take it out; and from the existence of many other specimens in the debris of the same quarry, which the workmen assured me had all come out of this bed, I believe them to be of frequent occurrence. Among the latter was one of unusual size, larger indeed in its horizontal dimensions than any other specimen I have seen, either from this bed or the Dirt above the Cap†. This, from its flatter form, may possibly

* Notwithstanding the apparent firmness of this rocky coast, great changes are constantly in progress there. An old boatman who conducted me, without having been asked a question, expressed in very strong terms his surprise at the alterations produced, to his own knowledge, within the last thirty years.

† The specimen is now in the museum of the Geological Society. It is of an irregular figure approaching to an oval, and measures 20 inches by 19 in its horizontal diameters, the vertical thickness varying from $6\frac{1}{2}$ to 9 inches. Another less perfect specimen which I saw in the same quarry, was about 9 inches thick, and its diameters not less than 34 and 30 inches. Of the Cycadeæ from the Upper Dirt-bed very few exceed 10 inches, in height and horizontal diameter. The largest I have seen is nearly 10 inches high, and about 12 in diameter near the bottom.

belong to the species *nidiformis* of Adolphe Brongniart (*Cycadeoidea megalophylla* of Dr. Buckland): but it deserves inquiry whether the specimens in the lower bed agree in all respects with either of those found in the upper one.

In the Isle of Portland, no trees have hitherto been found in this lower dirt; which, from its smaller thickness, might seem to have been less adapted to their production than the upper one. But if I can rely upon a single observation, part of a prostrated trunk exists in the Dirt below the Cap, in a section exposed on the west of the road leading from Upton (on the main land of Dorsetshire) to Poxwell. I came to this conclusion from observing that the inclined stratum of limestone over the bed including this specimen was distinctly botryoidal, and of great thickness,—two characters which accord with those of the Cap; while the stone below it contained Portland fossils. But I saw no Cycadeæ in the bed at this place.

11. "*Skull-Cap.*" The thickness of this bed in Portland varies from one to three feet, and it frequently swells out suddenly from 15 or 18 inches to double that thickness, and returns as rapidly to its previous dimensions. It is less uniform than the Cap, and sometimes has an obscurely conglomerated appearance, but, like that bed, consists of freshwater limestone, and is in some places botryoidal. It includes also, as Mr. Webster has stated, small cavities coated with minute rhomboidal crystals of carbonate of lime, like those found in the slaty beds above.

12. At the lower part, the "Skull-Cap" is closely attached to, or passes into, a seam of argillaceous matter, sometimes not more than half an inch, and seldom more than $2\frac{1}{2}$ inches thick, by which it is separated from the Portland stone. This seam appears never to be wanting in these quarries, and is much more uniform than the Dirt immediately above the Skull-Cap, which is very unequal in thickness: in some instances it is incorporated with, or adheres very closely to, the top of the Portland stone *.

13. and 14. The top of the *Portland series* consists of very fine-grained oolite, resembling the roe of fishes, and of a very light brownish hue. With the oolitic particles, other rounded fragments, less regularly shaped, are mixed and united by a calcareous cement, so that the whole compound is very like the recent conglomerates which abound on the shores of New Holland, of many of the Indian Islands, and of Bermuda; especially resembling the newly-formed masses of the last-mentioned islands, described by Lieut. Nelson in a paper lately read before this Society †. This oolitic portion is seldom more than four inches thick, and passes at the lower part into dark grey flint, in irregular concretions, which form an interrupted range near the top of the bed, and include the same petrifactions (but silicified), with those which abound in the limestone immediately around and below them. The stone below the flints, to a distance of from two to four feet from the top, is called "*Roche*" by the quarry-men, and is essentially continuous with the lower part of the bed; but it contains so many casts of shells (of which, indeed, it is almost entirely composed), as to be useless for the purposes of building, and is therefore always separated in the quarry. The remainder of this stratum, about 8 feet thick, is known in the island as the "White-bed", and is that which is now, almost exclusively, quarried for the market under the name of Portland stone. This and the lower strata of the formation, which are not worked at present, have been already described by Mr. Webster.

Among the fossils of the White-bed in Portland, are a Corbis?, *Cytheræa parva*, Lithodomus, *Pecten lamellosus*, *Perna quadrata*, Plicatula, *Terebra Portlandica*, *Trigonia gibbosa*, *T. incurva*.

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* The existence of Cycadeæ within three feet of the Portland beds being certain, it deserves inquiry whether they may not occur also in this lower and thinner Dirt-bed immediately above the stone.

† Proceedings, vol. ii. p. 81.

At Upway, this bed, or one of those immediately below it, is beautifully white, like chalk, and contains nodules of dark grey flint, frequently hollow and lined with quartz crystals, which it would be impossible, without attending to their fossils, and their geological position, to distinguish from those of the chalk. One of the characteristics of the best Portland stone, both of this and other beds, is that the blocks ring very distinctly under the hammer, giving out a clear and agreeable note.

(112.) It appears, therefore, that on the Dorsetshire coast the Portland strata are everywhere succeeded by a series of beds of freshwater limestone, alternating with beds of clay, or of a compound called "dirt", which contains carbonaceous matter and fragments of stone; and that two at least of these "dirt" beds, the first about three feet, the second about twelve feet above the top of the Portland series, include the remains of plants, which grew in the places where they are found; nor is it wholly improbable that similar remains may hereafter be discovered in some of the other and thinner beds of "dirt".

A point which Mr. Brown considers as well deserving of remark is, that the only remains of vegetables hitherto found in these strata, under the circumstances above described, belong to two nearly related families, Coniferæ and Cycadeæ, which have lately been regarded as forming a distinct class, characterized not only by the greater simplicity of the parts of fructification, but also by some peculiarities of internal structure, and thence have been considered as intermediate between Phanogamous, and Cryptogamous or Acotyledonous plants.

Another striking fact connected with the remains included in the "dirt beds" is, that they are composed almost entirely of silex, though surrounded either by limestone or by the mixed components of the dirt itself. The cavities in the petrified trunks are lined with minute crystals of quartz; and Dr. Prout, who has been so kind as to examine specimens of the coniferous wood taken from the confines of the Purbeck and Portland formations, in Portland, and other places to which I shall refer hereafter,—finds them all to consist almost wholly of siliceous matter, with very slight traces only of carbonate of lime and of iron; some of the darker parts of a specimen, from the Vale of Wardour containing also bituminous matter. The Cycadeæ likewise are described by Dr. Buckland as being almost entirely siliceous, "varying from "coarse granular chert to imperfect chalcedony"*.

(113.) The great abundance of small, worn, fragments of shells and stone at the top of the Portland formation, is what might have been expected on the surface of an island of small height, just protruded from the sea,

* Geol. Trans., 2nd Series, vol. ii. p. 398.

perhaps so gradually as to have been near the surface for some time before its emersion. The next step, in the series of revolutions which produced these strata, must have been the diffusion of fresh water over the new land, from which the "Skull-cap" was deposited; and this was followed by a drying up or retirement of the water, so as to disclose and convert into dry land the lower of the two beds of clay, or dirt, which now contain the Cycadeæ. I am not sufficiently acquainted with the habits of the recent plants of this family, to form any opinion as to the length of time necessary for their acquiring the size of the specimens now found petrified, nor to judge how far the rapidity of their growth would be modified by climate: but all the known species are said to be of slow growth; and being found at Japan, as far north of the equator as 40°, and at the Cape of Good Hope and Port Jackson, in the southern hemisphere, about latitude 34°, they cannot be considered as strictly tropical productions.

A *second* submersion of the surface in fresh water must have followed the production of the Cycadeæ in this lower bed, from which the "Cap" was accumulated, to a thickness of between seven and ten feet, and the "Black Dirt" deposited above it; and a *third*, and apparently more durable submersion, still in fresh water, must afterwards have taken place, by which the "slate" and a great part of the Purbeck strata were produced. In this last case the water seems to have been at first unmixed, but to have become after a time accessible to the sea; since not only does the Purbeck formation contain a thick bed of oyster-shells, but thence upwards, throughout the Wealden, oysters are found, in strata which in several instances alternate with others abounding in freshwater shells.

(114.) Mr. Lyell has pointed out the resemblance between the geological events which produced the strata of Portland Island, and those which are known to have occurred at the mouth of the Indus, from the effect of successive earthquakes connected with volcanic eruption*; and it is clear that all the changes above supposed to have taken place,—depression and elevation of the land, through comparatively small depths and at different periods, with alternate though irregular submersions both in salt and fresh water,—have been produced in that region, not only within the period of tradition, but many of them so recently as in 1819. Among other facts, it is stated, that for some years after the earthquake of Cutch, which happened in that year, "the withered Tamarisks and other shrubs protruded their tops above the "waves, in parts of the lagoons formed by subsidence, on the site of the

* Principles of Geology, 4th edition, vol. ii. p. 237–242.

"village of Sindree and its environs. Every geologist," Mr. Lyell justly remarks, "will at once perceive, that forests sunk by such subterranean "movements may become imbedded in subaqueous deposits both fluviatile "and marine, and the trees may still remain erect; or sometimes the roots "and part of the trunks may continue in their original position, while the "currents may have broken off or levelled with the ground their upper "stems and branches*."

(115.) It is very desirable that the examination of the Portland quarries should be repeated from time to time: for as the valuable stone lies deep in the series, and it is necessary, for the purpose of obtaining it, to remove the whole of the incumbent matter, the features described in this paper are constantly undergoing a process of destruction; while, on the other hand, new facts are continually brought into view, which are lost if not observed at the moment. The greater part of the phænomena described by my predecessors had thus disappeared when I visited the island, and a few hours might have removed the fossils which I observed in the bed below the Cap. Geologists may assure themselves that the trouble of a journey to Portland will be most amply rewarded; since few places, it is probable, in the world, exhibit with such distinctness and in so small a space, phænomena of more extraordinary interest, or of greater importance to theory.

(116.) The strata, abruptly cut off by the sea on the west coast of Portland, are found no more in that direction in England†; nor do they occur on the opposite coast of France immediately on the south, which consists of the primary masses of Guernsey, Auvigny, and the main land about Cherbourg. On the east of the last-mentioned promontory, where they might be expected to appear among the beds beneath the chalk between the mouth of the Seine and Bayeux, their presence, I believe, has not been distinctly ascertained. And on the north of the Seine they must be far below the level of the English Channel, at least as far as Etaples, where the rocks upon the shore consist of chalk with flints *in situ*. The Portland beds, with a thin covering of the lowest Purbeck strata, rise from beneath the chalk and green-sand on the south of Equihen in the Lower Boulonnois, and are found all along the cliffs thence to the north of Cape Gris-nez, where they again give place to the superior strata. They have not yet been discovered, so far as I am informed, further to the north in Europe.

* Principles of Geology, 4th edition, vol. iv. p. 274.

† The most western point where the Portland strata have been found in England, is on the main land near Portisham, twenty miles west of Lulworth Cove. See p. 15. of this volume.

(117.) *List of Fossils from the Beds below the Chalk, on part of the Coast of Dorsetshire.*

[*Upper Green-sand.*]

Cirrus depressus. Worbarrow Bay.

Exogyra conica. Face of the Hill top, W. of Osmington Mill.

E——— lævigata. Worbarrow Bay.

Gryphæa vesiculosa. Swanage Bay, under Ballard Hill. Hill top, W. of Osmington Mill, with stems of Siphonia.

Ostrea, new. Between Ham Cliff and Osmington Mill.

Pecten asper. Swanage Bay. Hill top, W. of Osmington Mill.

P—— orbicularis. Swanage Bay. W. of Osmington Mill.

P—— quadricostatus. Swanage Bay. Worbarrow Bay.

P—— quinquecostatus. Swanage Bay.

P—— ————————. A very convex variety (young ?). Worbarrow Bay.

Serpula antiquata. Swanage Bay

Siphonia. Stems. Worbarrow Bay. Hill top, W. of Osmington Mill.

Terebratula pectita. Swanage Bay.

Vermetus concavus. Swanage Bay. Osmington Mill.

[*Gault.*]

Mya mandibula. Punfield*, Swanage Bay.

[*Weald Clay.*]

Cyclas media. Punfield. In thin beds of bluish limestone, encrusted with fibrous carbonate of lime ("cone in cone").

C—— membranacea. Punfield.

Cypris tuberculata. Pl. XXI. f. 2. Punfield.

C—— Valdensis. (*C. Faba*, Min. Con.) Pl. XXI. f. 1. Punfield.

Exogyra? Punfield. In brown clay.

Melanopsis? attenuata. Pl. XXII. f. 5. Punfield. In blue clay.

M———? tricarinata. Pl. XXII. f. 4. Punfield. In blue clay.

Ostrea. A plicated species. Punfield. In a bed of stone subordinate to the Weald clay, the greater part composed of shells; with a striated bivalve (a Cardium ?).

O——. A smooth species. Punfield. In greenish sandy stone, coated with fibrous carbonate of lime.

Paludina acuminata. Punfield.

P——— elongata. Punfield. With *Cyclas media*, in greenish grey sandy clay.

Unio. Punfield. In thin, slaty, dark bluish clay.

Saurian Reptiles. Fragments of bone of a Saurian; and the teeth apparently of a Crocodile. Punfield.

Wood. Coniferous, silicified, in fragments. Punfield.

* *Punfield* is a small nook or recess on the north of Swanage Bay, between the ridge of Ballard Down and the sand-cliffs.

[*Hastings Sand.*]

Cyclas media. Sand-cliff between Swanage and Punfield. In nodules of clay-iron-ore, with Paludinæ; also in hard subcalcareous grit.

Paludina elongata. Same place and situation.

Unio. One or more species occur in the concretions of grit within the sand-beds, between Punfield and the town of Swanage.

Saurian Reptiles. Large bones of the Iguanodon have been found loose on the shore at the foot of the sand-cliffs near Swanage, by the Rev. T. O. Bartlett; (see Dr. Buckland's Notice, already referred to*;) but their precise place in the cliffs is still to be ascertained.

Wood. Large portions of the stems of silicified coniferous trees have been found on the shore under the sand-cliffs in Swanage Bay, by the Rev. T. O. Bartlett. The stone into which they are converted is of a very dark brown colour, receives a fine polish, and does not effervesce with acids.

[*Purbeck Strata.*]

Corbula alata. Pl. XXI. f. 5. Numerous in slaty limestone, at Upway, on the north of Weymouth, with *Cyclas media.* Durlstone Bay: Isle of Purbeck.

Cyclas media. Pl. XXI. f. 10. This fossil occurs throughout the series of Purbeck strata, and is one of the most abundant fossils of the formation, some of the beds being almost entirely composed of it. Upper beds of the series, at Peverell Point, and Durlstone Bay. At Upway, west of the road, 50 feet above the "Cap".

C—— angulata. Pl. XXI. f. 12. In "Quarry vein", one of the strata worked for stone, near Swanage. In hard stone resembling the lower chalk, when indurated; Durlstone Bay. Of large size, in slaty stone, at Upway, N. of Weymouth.

Cypris. Casts, in transparent carbonate of lime, of the interior of one or more small species of this genus, occur in great abundance in the beds of slaty limestone, which frequently includes rhombic crystals of carbonate of lime, at the bottom of the strata above the "Dirt bed", as well as in the "Cap" over the Portland stone: but it is difficult to determine the species, as the external surface is commonly wanting. In a few instances an exterior spine or prominence, like that of *Cypris spinigera*, Pl. XXI. f. 3., is perceptible; and in others the protuberance at the end of the valves, represented in the figures of *C. Valdensis*, Pl. XXI. f. 1., was observed. It is not, however, improbable that some of the casts may belong to species different from both of these. Isle of Purbeck, and coast thence to the west of Lulworth Cove. Quarries at Upway, north of Weymouth. Isle of Portland: in the "slate".

Exogyra bulla. Pl. XXII. f. 1. Durlstone Bay.

Ostrea distorta. Pl. XXII. f. 2. Durlstone Bay. The bed called "Cinder", about the middle of the strata which are worked for stone, consists almost entirely of this and other species of oyster.

* Proceedings of Geol. Soc., vol. i. p. 159.; and Geol. Trans. Second Series, vol. iii. p. 421. *et seq.*

Ostrea. A new species? Durlstone Bay. West side of Lulworth Cove, in bluish sandy stone. Durdle Cove, in a bed like the "Cinder".

Paludina carinifera. W. of Lulworth Cove, with *Unio compressus*, and a pearly oyster, in the uppermost of the Purbeck beds, some of which are almost entirely composed of shells of Paludinæ. Also, with bones of fishes, in very blue compact and sparry limestone.

P.——— elongata. Peverell Point. Abundant in the uppermost beds of the Purbeck stone, with much green matter. Durlstone Bay, with *Cyclas media.*

P.——— Sussexiensis. Pl. XX. f. 6. Peverell Point; in splintery limestone, with disseminated calcareous spar. Durlstone Bay.

Unio compressus. Durlstone Bay; in oolitic stone, with *Cypris.*

U.— new species? At the upper part of the series; in beds composed of carbonate of lime, apparently derived from the presence of these shells, with a large proportion of green matter (silicate of iron). East side of Lulworth Cove. Worbarrow Bay. [The occurrence of bivalves in this place is mentioned by Mr. Webster, Geol. Trans., 2nd Series, vol. ii. pp. 39, 40.]

Reptiles.—*Turtles.* Fragments of the shell and bones of Turtles are not unfrequent, and even entire skeletons are sometimes found in the Purbeck strata.

Saurians. Fragments of bone, and teeth.

Fishes. Palatal bones: Durlstone Bay. The scaly remains, also, of different species, are frequent in the slaty strata of the Purbeck stone.

Plants. Near the junction of the lower slaty beds of the Purbeck with the Portland stone, large trunks and branches of coniferous wood are found in great abundance in the "Black Dirt" above the "Cap", in the Isle of Portland, and on the coast east of Lulworth Cove; and in the dirt below the "Cap"? between Upton and Poxwell.

A Cone, represented in Plate XXII. f. 9., and stated to be "from Purbeck", is in the Museum of the Geological Society. It has some slight resemblance to the cone of a Dammara of the Moluccas.

Cycadeoidea (*Mantellia* of Adolphe Brongniart, "Prodrome", &c.). Remains of at least two species of Cycadeæ occur in the Isle of Portland, along with the trunks of coniferous trees, in the "Black Dirt" above the "Cap"; and those of at least one species, also in the dirt or clay, between that bed and the "Skull-Cap".

[*Portland Stone.*]

Ammonites biplex. Isle of Portland.

A.——— new. Isle of Portland.

Cerithium? excavatum (*Turritella excavata*, Min. Con.). West of the Isle of Portland.

Cytherea parva (*Venus*, Min. Con.). West of Portland, in the flint of the "Roche".

Lithodomus. New. Upper part of the "White Bed", Portland.

L.———. Another species? Same situation.

Monodonta. New. Lowest beds of the Portland stone. Near Blacknore, Isle of Portland.

Pecten lamellosus. Lowest beds of the stone. Same situation.

Plicatula? Casts of the interior, numerous in the "Roche" immediately over the "White bed". Portland.

Terebra Portlandica. Pl. XXIII. f. 6. Very numerous in the "Roche": also in the "White bed". Portland.

Trigonia incurva. Pl. XXII. f. 14. (Miss Benett*: Pl. XVIII. fig. 2.) In the "White bed". Portland.

T—— gibbosa. Frequent in the "Roche". Portland, and elsewhere on the coast.

T—— ——. A variety, approaching to *incurva*, but less oblique. Portland.

Venus parva. (See *Cytherea.*)

[*Portland Sand.*]

Ammonites giganteus. Cross-roads above Kimmeridge Farm, on the north-east. Isle of Purbeck.

A——. New species. In concretions of splintery indurated marl, or soft limestone. Lowest beds of the Portland sand. Emmet's Hill: Isle of Purbeck.

Cucullæa. (A small species.) Portland.

Exogyra nana. West side of Portland Island, on an Ostrea.

Ostrea lævigata. East side of Portland.

Panopœa depressa. (*Mya depressa*, Min. Con.) In concretions of dark bluish grey indurated marl. Lower part of the sand. Emmet's Hill: Isle of Purbeck.

Pecten. A new species? Upper part of the sands. Blacknore, Portland.

Serpula tricristata. Pl. XXIII. f. 8. East side of Portland. *Quæ.* in Kimmeridge clay?

S—— variabilis. Pl. XXIII. f. 7. East side of Portland. *Quæ.* in Kimmeridge clay?

Trigonia clavellata†. Cross-roads above Kimmeridge Farm on the north-east. Isle of Purbeck.

Fishes. *Scales* of fishes are found in strata apparently belonging to this formation, under Gad Cliff, in the Isle of Purbeck.

Rays of dorsal fins (see the abstract of a paper by M. Agassiz, Proceedings of the Geological Society, vol. ii. p. 101.) occur in nodules either of this formation or of the Kimmeridge clay, on the east coast of Portland.

[*Kimmeridge Clay.*]

Ammonites biplex. Numerous in the bituminous shale of Kimmeridge Bay, with transparent sulphate of baryta: sometimes along with an Ostrea.

* "A Catalogue of the Organic Remains of the County of Wilts;" 4to, with 18 plates. Warminster, 1831.

† Besides the shells mentioned above, two or three other bivalves, of which the genera are indistinct, have been found in the Portland sand, at Emmet's Hill and other places, in the Isle of Purbeck.

Ammonites mutabilis. Young.
Astarte cuneata? In firm brown shale. Kimmeridge Bay.
Panopœa depressa. Kimmeridge Bay?
Ostrea deltoidea. East of Portland. *Quæ.* in Portland sand?

Fishes. *Teeth.*
Rays of dorsal fins.

[*Weymouth Strata and Oxford Oolite*.*]

Ammonites circularis. Pl. XI. f. 20. In reddish sandy beds above the pisolite. Abbotsford.
Astarte cuneata. In ferruginous sandy stone. Near Weymouth†.
Belemnites fusiformis. North of Weymouth.
Clypeus clunicularis. (Smith, "Strata Identified"—Coral Rag, fig. 6.) Weymouth; in oolitic sand.
Exogyra nana. In whitish oolitic stone, between Ham Cliff and Osmington. North of Weymouth.
Gervillia aviculoides. In the coarse grit between Ham Cliff and Osmington Mill.
Melania Hedingtonensis. In oolitic sand, near Weymouth. In reddish sand-rock, above the pisolitic clay, near Abbotsford.
Modiola bipartita. In hard reddish clay. Osmington.
Ostrea. A thick-shelled species, near Abbotsford, in oolitic sand, at the top of the oolite.
O——. Species? Between Ham Cliff and Osmington Mill.
Nerinea Goodhallii. Pl. XXIII. f. 12. Cliff east of Osmington Mill; in coarse rag. Mr. Goodhall.
Pecten annulatus. In sandy beds, near Osmington?
Pullastra? In marly pisolite at the top of the Oxford oolite, near Backwater, going from Wycke Church; Weymouth.
Terebratula inconstans. Near to Osmington, in blue clay. Boat Cove.
T————. New? Oval: reddish beds above the pisolite. Abbotsford.
Trigonia clavellata. Abundant on the shore between Ham Cliff and Boat Cove. In ferruginous sandstone near Weymouth, with *Astarte cuneata.*
T—— *costata.* Osmington.
Trochus Sedgwickii (olim *T. reticulatus*). From the reddish beds above the pisolite. Near Abbotsford. Upper part of the Coral rag, and lower of the Kimmeridge clay. Near Weymouth.

* As the sands and clays of the Weymouth group pass insensibly into the Oxford oolite, it is difficult, and perhaps unnecessary, to distinguish them by a definite boundary. The fossils appear to be the same.

† Most of the specimens here referred to, from the neighbourhood of Weymouth, are in Mr. Goodhall's collection.

Devonshire.

(118.) The coast on the west of Portland as far as Sidmouth has been described by Dr. Buckland and Mr. De la Beche* in these Transactions; where also the former has published a map of the coast between Teignmouth and Portland, with views from Sidmouth to Bere Head, and from Lyme Regis to the vicinity of Weymouth and Portland †. The coast of Devonshire, therefore, requires no additional illustration; and for the local extent and distribution of the strata in the interior of that county, it is now in my power to refer to the beautiful Geological Map recently completed by Mr. De la Beche‡, and to be followed by an explanatory memoir and sections.

As the beds between the chalk and the bottom of the lower green-sand on the west of Purbeck appear to have coalesced, and are no longer marked by the previous subdivisions, the green-sand of Devonshire may be regarded as the equivalent of the whole series. The lower green-sand seems especially to have been reduced in bulk, in its progress westward. The gault has wholly disappeared; but some of its characteristic fossils are found in the sand and grit of the cliffs on the west of Lyme. At the bottom of the sands the boundary is everywhere distinct: and the plateau which shoots out to the west of Dorsetshire is found successively in apposition with the lower oolite, the lias, and new red sandstone; while its remotest portion rests on grauwacke slate. Throughout the greatest part of the tracts thus occupied, the green-sand forms a flat-topped, uniform cap, investing the hills, as far west as Sidmouth on the coast, and the Blackdown range on the north of that place, nearly to Wellington; and finally, it constitutes an extensive outlier, from the north-west of Teignmouth to Penhill, about six miles south-west of Exeter, which caps the heights of Great and Little Haldon, and is detached from the more continuous tract above mentioned by an interval of more than twelve miles, occupied by the new red sandstone.

Several insulated portions of chalk, however, still remain above the eastern portion of the green-sand platform, especially upon the coast between Sidmouth and Lyme, and along the line from Beaminster through Chard and White Stanton. The transition from the chalk to the sands is well seen at some of the junctions, especially on the south-west of Axmouth, where the strata

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* See their joint memoir at the commencement of the present volume; Geol. Trans., 2nd Series, vol. i. p. 40, &c.: and a separate paper by Mr. De la Beche, vol. ii. p. 109, &c.

† Ibid., vol. i. p. 95, &c.

‡ "Ordnance Geological Map of Devon, and of portions of Cornwall and Somerset, by H. T. "De la Beche, Esq.," in eight coloured sheets.

rise a little towards the north from the point of *Bere Head*, so that sections of the subjacent beds are exposed in the cliffs on both sides of that promontory. The beds immediately below the chalk are best seen on the shore towards Branscombe, and have been described by Mr. De la Beche, who has also mentioned the quarries near that place, from which stone corresponding in situation to the firestone of Surrey is extracted *.

The section at *Whitecliff*, on the east of Bere Head and of the village of Bere, is thus:

	Feet.
1. *Chalk*: white at top, yellowish below; very sandy, containing throughout numerous small nodules of flints, both in bands and irregularly disseminated,—more numerous at top. Vermetus is a frequent fossil here ..... [At the bottom is a course of very sandy chalk, including concretions or lumps of greater firmness, produced apparently by the unequal diffusion of the siliceous matter.] Total, 60 or 70 feet.	60
2. Yellowish grit, with green stripes	10 to 12
3. A conglomerate of lumpy concretions, and apparently of *fragments* also, of hard matter; with green particles between the lumps. Petrifactions numerous ..... About	5
4. Beds of *chert*; both continuous and in irregular concretions, alternating with bands of siliceous grit; from 3 or 4 feet down to a few inches in thickness .... Total, about 40 or	50
5. Bluish green and grey sand, with bands of more solid texture, increasing gradually in number towards the bottom ..... About 30 to	40
6. Bluish moist sand, in some places almost black, abounding in petrifactions, and becoming darker in colour downwards, the hue apparently depending on the degree of moisture. This bed contains Gryphites, traces of large Ammonites, Vermetus, and numerous stems of Siphonia ..... About 50 or 60 feet. [This darkly coloured sand contains at the lower part large nodules, consisting of greenish grit, in courses from 3 to 6 feet apart. The stratum is in immediate contact with the red marl. Springs come out at the junction.]	60
7. *Red marl.* At the top containing gypsum in nests; throughout including spots and patches of a light greenish grey, and alternating with beds, of irregular thickness, of the same hue. ("Bunter sandstein"?)	

I have inserted the preceding list from notes taken during the summer of 1825, as its coincidence with that since published by De la Beche, shows the correctness of both. It will be evident, upon comparing these lists with each other, and with that of the sands near Lyme, that the group which here succeeds the chalk is the equivalent of the Upper green-sand; the local variations in this formation on the Devonshire coast not being greater than those of the range which extends from Folkstone into Surrey; in the course of which the Upper green-sand is in some places almost wholly wanting, while in others it acquires great thickness, and often contains beds almost suddenly developed, no trace of which is to be found in the intermediate spaces. The *grizzle* of Sutton quarry, and the *Beer-stone*, are varieties of the siliciferous stone on the confines of the chalk and Upper green-sand, which under various denominations, "Fire-stone", "Totternhoe-stone", &c., occurs very generally in that part of the series, and is everywhere in request for building. The total absence of blue clay is remarkable in the section at Bere. The place where it might have been expected is immediately beneath the cherty groups of Mr. De la Beche's figures 1 and 2 †; and if the gault were added to those sections, estimating

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* In a large pit or quarry at the bottom of the chalk, near Sutton and Widworthy, a stone, called *Grizzle* by the quarry-men, is dug in the situation of the firestone. The beds are altogether about 5 feet in thickness. It contains green particles, and does not burn to lime. Among its fossils is *Catillus Cuvieri*.

† Geol. Trans., 2nd Series, vol. ii. pl. 16.

its thickness only at 100 feet, the total thickness of the whole of the green-sand group would not be more than 300 feet: the actual thickness of the sands being nearly 200 feet at Lyme Regis; and at *Whitecliff*, according to my own measurement (it is not stated by Mr. De la Beche), about 160. The beds below this cherty group represent Mr. De la Beche's "*Fox mould*" (No. 6. of the above list); and are apparently the equivalent of the upper and more ferruginous group of the lower green-sand: the lower, moist, and dark-coloured sands, with the "cowstones" at the bottom, being probably the equivalent of the middle, dark, cohesive sand of Sandgate (24.), Shanklin (192.), and Black-gang Chine (195.);—the "cowstones" representing the calcareous group of Hythe, &c. This occurrence of nodules dispersed in sand is frequent wherever calcareous strata are near their termination; as in the cases of the Portland stone, the lower oolite, &c.

I have stated these resemblances that the whole case may be before the reader: but in the vale of Wardour,—where the distinct occurrence of a bed of blue clay with the characteristic fossils of the gault, leaves no doubt as to the place where the sands are divided,—the inferior beds of the Upper green-sand acquire a character very like that of the Lower in other places; and the latter is either wholly wanting, or very imperfectly represented.

(119.) *Blackdown Hills.*—In approaching the hills of green-sand, their aspect on every side is the same, precisely resembling that of the long flat-topped ranges of this formation, and of the Bagshot sands, in Kent, Surrey, and Hampshire. The surface is barren, and the chief products, at present, seem to be furze and heath; though in former times, it is reported, extensive woods were here. I ascended first from Wellington on the north of the Blackdown Hills, and found red marl for more than two thirds of the height, so nearly resembling some of the sandy and variegated clays of the Wealden, especially of the Hastings sands, that but for the presence of sulphate of lime in crystalline nests, it would be difficult to distinguish them; while the greenish varieties of the marl also very much resemble some of the beds above the chalk in the Isle of Wight. From Beacon Hill, on the south-west of Wellington, the uniform level of the summits is very striking, the eye being carried over the whole range without interruption, and the ravines quite lost sight of. The absence of the remains of chalk from the debris on the top of these hills is remarkable: I searched long, but did not see a single fragment of flint, all those which I could find being chert, easily distinguishable from chalk flints. In the yellowish sand near the surface, at the Barnscombe side of the hill, brown iron ore is found, in polished fragments of very high lustre, resembling those of the lower green-sand at Sandown Bay in the Isle of Wight (1200; p. 188.), of Surrey (59.), and Western Sussex.

Although the strata forming these hills are in a general view continuous, the whole country is divided by fissures, attended in some cases with considerable dislocation; for an account of which I refer to Mr. De la Beche's Map of Devonshire, and his essays on Theoretical Geology*.

* "Researches in Theoretical Geology," 1834, p. 185, &c.

Three nearly parallel lines of fault, running about north and south, are especially remarkable in Mr. De la Beche's Map; one on the east of the county, passes from about a mile north of Combe Beacon, through the hill which bears that name, along the valley of Wambrook, and the streamlet west of Chardstock, across the Axe, to a point about two miles east of Axminster; the total extent to which it has been traced being about ten miles. A second fault extends from Balay Down on the north of Challenge, through Membury, to the bed of the Yart south of Yetlands; the lias being thrown up into immediate apposition with the green-sand through a great part of its course, as is also the case in the preceding fault near Wambrook. A third and shorter fissure, about three miles in extent, reaches from the north of Wilmington to Stockers, about two miles south of Widworthy, crossing the main London and Exeter road, and skirting the eastern slope of an outlying hill of chalk on the south of that village.

(120.) The hills which have furnished the greater number of the Blackdown fossils form the western range of the group between Honiton and Wellington, about six miles to the south of Beacon Hill above mentioned. Their escarpment, between Punchey Down on the north, and Upcot Pen on the south, is distinguishable at a great distance by the white line produced by the refuse thrown down from the openings of the sithe-stone pits; the heaps thus formed constituting an almost continuous horizontal stripe in the face of the hill.

The whole thickness of the sandy strata above the red marl in this part of the country, seems to be about 100 feet. The contrast between the barrenness of the upper sands, and the comparative fertility of the marl beneath, is everywhere very conspicuous; and it would seem from the unequal ascent of the hedge-rows and cultivated ground that the surface of the marl is very uneven.

The strata which afford the whetstones are about 80 feet below the top of the hill, to which they are parallel. The mines (or "pits" as they are called) are driven in direct lines into the hill, almost horizontally, and in some cases to considerable distances. The stony masses from which the sithe-stones are cut, are concretions of very irregular figure, imbedded in looser sand, nearly resembling those which occur in the upper division of the Lower green-sand near Sandgate (21.): and though very irregular in shape, marks of the stratification of the sand can be traced on their outside. The masses of which the sithe-stones are made, vary from 6 to about 18 inches in diameter, and the beds which afford them would form a total thickness of about 7 feet, of which about 4 are fit for that purpose; the looser stone at the top and bottom being employed for building.

The following is a sectional list of the beds in one of the principal sithe-stone pits at Punchey Down, which, I was informed, was a fair representative of the whole:

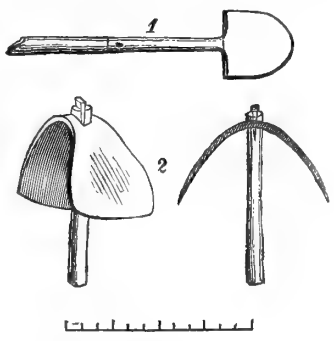
	Ft. In.	Ft. In.
1. Reddish sand rock, extending upwards to the top of the hill.		
2. "*Fine vein*". Concretions of firmer consistence; the best for sithe-stones. [Shells are found in all the strata here, but abound remarkably in this one, and in the "*rock*" beneath it]	0 2	to 1 0
3. "*Top sand rock*"; sand with irregular concretions; of no use.....	3 0	to 4 0

	Ft.	In.		Ft.	In.
4. "*Gutters*"; concretions of stone in 4 or 5 courses, in the sand. This bed is that most commonly used for sithe-stones	3	0	to	5	0
5. "*Burrows*"; stone and sand of the same kind, but used only for building ..	2	0	to	3	0
6. "*Bottom stone*"; a range of concretions, affording excellent sithe-stones.... [These concretions sometimes extend downwards, even to 5 feet, in the sand.]	0	2	to	0	6
7. "*Rock sand*"; chiefly sand, with fewer concretions; of no use				4	0
8. "*Soft vein*"; concretions which afford excellent sithe-stones	0	2	to	0	6

The strata below are not known to the workmen. The total thickness, therefore, of the strata which furnish the material for sithe-stones, including the rejected sand and rubbish, is from 12 to 18 feet; the whole of which is removed in cutting the drifts or galleries.

Sithe-stones.—As the manufacture of these stones occupies a great number of the inhabitants of the country, and is of some commercial importance, a large proportion of the whole quantity used in England being supplied from the Blackdown pits*, I shall here describe the method of preparing them.

The sithe-stone men take from the owners of the soil the privilege of digging for stones, leaving 40 yards on each side between the drifts (or "pits" as they are called). There is no limitation as to depth, and the drifts are commonly pushed to about 300 yards inwards, greater distances not repaying the labour of bringing out the sand. When first taken out, the stone is greenish and moist, and can be cut or chopped with ease. The tools employed are a sort of axe or adze with a short handle (fig. 2.), called a "basing-hammer", which is ground to a sharp edge. These are made at the adjacent village of Kentisbere. The other tools are "picks", without any peculiarity of structure, and "hollowing-shovels" (fig. 1.), for digging the masses of stone out of the sand.



For the purpose of cutting the stones, a vertical post of wood, or "anvil", is so fixed in the ground as to stand between the knees of the workman, who sits upon a sort of bench built of stone, with some strong pieces of old leather attached as a defence to his left knee. He first, with the edge of his "basing-hammer", splits from the blocks, upon his knee, long portions approaching to the shape of the sithe-stones†; and then cuts or chops them down, nearly to the required size, upon the anvil and his knee,—just as a carpenter cuts timber with an adze. After being thus rudely shaped, the stones are "hewn" to the proper dimensions with a larger "hammer", and then rubbed down with water by women, on a large stone of the same kind; and when dried they are fit for sale.

The stones when finished vary from about ten to twelve inches in length; some have the shape of a portion of an almond, with the ends and sides cut square, and about 2 inches by $1\frac{1}{2}$ in thickness; others are almost cylindrical, but smaller at each end, with the sides a little curved; the diameter in the middle about 2 inches.

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* Sithe-stones are also manufactured in great numbers in Derbyshire from the sandstone of the coal formation. (Farey's Derbyshire: 8vo, 1815; p. 437-8.)

† The masses of stone, I believe, split best in the direction of the lines of stratification of the sand.

A good workman can cut out of the blocks about seven dozen of the stones per day *. They are sold by the makers chiefly to one merchant at Honiton, who supplies the retail dealers. The prices (in 1825) varied from 2*s.* per dozen, for the finest stones, 11 to 12 inches long, down to 8*d.* a dozen for the coarsest, 10 inches in length.

(121.) Between the sand and the red marl beneath it, I did not observe any perceptible valley, nor any indications of an intermediate bed of clay.

In a lane at Standhill, between Wellington and Bryants, about half a mile from the latter place, the strata were thus; belonging to what is, here, the upper part of the new red sandstone.

	Ft.	In.
1. Dusky red clay, or marl, adhering to the tongue	2	0
2. Light greenish clay, with glittering particles (mica) about	1	0
3. A band of greenish sandy clay, in part concreted and sparry, irregular in thickness	0	9
4. Greenish clay, like No. 2. about	2	0
5. Reddish clay, like No. 1., in part concealed at the bottom		

These beds are scarcely distinguishable from those at the top of the Hastings strata, at the back of the Isle of Wight.

At Kentisbere, about 1½ mile west of the escarpment of the hills which contain the stone pits, the strata of red marl appeared to dip to the south-east. They consist of coarse gravel and conglomerate of a dull red hue, under firm, red, marly sand: and here there is a distinct alternation of yellow sand with the red marl, the former appearing below the marl in thick stony beds at least 50 feet thick. A rough section at this place is given in Plate X. a. No. 12.

(122.) *Fossils.*—The great numbers and variety of the Blackdown fossils may be ascribed in part to the extent of the quarries, which have been dug for sithe-stones during a long series of years; but the beds themselves must be more than commonly fertile in these productions, since the entire thickness of those from which almost all the specimens have been obtained, does not exceed twenty feet. Their beautiful preservation arises, in some measure, from the loose sandy character of the matrix in which they are imbedded, and from which they are easily detached: but the composition of the fossils themselves has also contributed to this effect; for, with very few exceptions, the shells are converted into chalcedony, and the

* Mr. Meade, of Chatley near Bath, has favoured me with the perusal of a letter from the Rev. Mr. Steinhauer, dated in 1813, in which, after an account of the whetstone pits at Blackdown, it is stated that the preparation of the sithe-stones is so injurious to the health of the workmen, that in the little village of Punchey Down, which is inhabited exclusively by the stone-cutters, the writer saw but one elderly person, and was informed that few reached the age of forty. The complexion and figure of the greater number he describes as striking and interesting in a high degree; but it was the hectic aspect, and itself a proof of disease. When I visited the place about twelve years afterwards, I did not meet with anything that called my attention to the health of the quarry-men: but the facts described by Mr. Steinhauer are analogous to those which prove the frequency of consumption among the grinders of needles, and the workmen at some other trades, where minute particles of solid matter are diffused in the air, and taken into the lungs.

whole of their calcareous matter has disappeared*. This is the more remarkable, as in many other places, indeed generally, the fossils of the green-sands consist of carbonate of lime; the absence of which, however, is prevalent throughout the sand of the Blackdown Hills, which seldom effervesces with acids; and to this circumstance, probably, the excellence of the concretions which they contain, as a material for whetstones, is to be attributed.

A very extensive collection of fossils from the Blackdown pits was formed by the late Mr. Miller, of the Bristol Institution; and is now in the museum of that establishment. The Managers were so good, at my request, as to allow the whole of this valuable collection to be sent to London, where it was examined by Mr. Sowerby, by whom the subjoined list, and the annexed plates, have been prepared: and I have great pleasure in expressing my obligation for this mark of their confidence and favour.

(123.) *List of Fossils from the Sands of Blackdown, and of some other places in Devonshire*†.

Ammonites auritus. M.
A— denarius. A thin crust of hydrophanous chalcedony, over spongy siliceous stone. M., Min.Con., F.
A— dentatus. M.
A— falcatus. M.
A— Goodhallii. Blackdown. M., F., Min. Con. Near Lyme. D.
A— Hippocastanum. Dowlands cliff, near Lyme. Min. Con.
A— lautus. M.
A— splendens. Pinhay, in hard green sparry stone. F.
A— triserialis. Pl. XVIII. f. 27. Mr. Sowerby's museum.
A— tuberculatus. M.
Ammonites varians. A gibbose variety. M. Pinhay. F.
A— varicosus. M., F.
A— Another species, probably new. M.
Amphidesma tenuistriatum. M. Pl. XVI. f. 7.
Arca rotundata. M. Pl. XVII. f. 8.
Astacus, Portions of. Pinhay. Miss Anning. Near Lyme. D.
Astarte concinna. Pl. XVI. f. 15. M. Mr. Sowerby's museum: D.
A— cuneata. F.
A— formosa. M. Pl. XVI. f. 16.
A— impolita. M. Pl. XVI. f. 18.
A— lineata. F.

* See Conybeare; "Outlines," &c., p. 128.

† All the Fossils in this list are from the Whetstone Pits at *Blackdown*, except those to which a different locality is assigned: and all the specimens from the Blackdown pits, where a different composition is not mentioned, are casts in chalcedony.

The letter M. denotes that the specimen is from the collection of the late Mr. Miller, now in the museum of the Institution at Bristol: Min. Con. refers to Mineral Conchology: D. to a paper of De la Beche, on the chalk and sands in the vicinity of Lyme Regis and Bere; Geol. Trans. 2nd Series, vol. ii. p. 109 et seq.: F. to the Author's Collection.

Astarte striata. M. Min. Con.

A— multistriata. M. Pl. XVI. f. 17.

Auricula? incrassata. M., F. Min. Con.

A—? Two species, not figured. F.

Avicula anomala. M. Pl. XVII. f. 18.

Cardium Hillanum. F., M., and Min. Con.

C— *proboscideum.* M. Min. Con.

Corbula truncata. M. Pl. XVI. f. 8.

C— *elegans.* F., M., Min. Con.

C— *gigantea.* M., Min. Con.

C— *lævigata.* Min. Con.

C—. Two other species, probably new. M.

Cucullæa carinata. M. In red jasper-like stone. Min. Con.

C— *costellata.* M., F. Min. Con. Col lumpton, Devon: near Lyme. D.

C— *decussata.* Pinhay or Bere? F., Min. Con.

C— *fibrosa.* M., F. The sand-rock of this specimen is very like that of Risborough, near Hythe. In red jasper-like stone or chalcedony. Min. Con.

C— *glabra.* Pinhay. In firm sparry grit. M., Min. Con. Near Lyme. D.

C— formosa. M. Pl. XVII. f 7.

Cyprina angulata. (*Venus angulata.* Min. Con.) The shell about one third filled with chalcedony, as with a liquid. In some specimens the shell, the place of which is now occupied by chalcedony, had been bored through, as represented in the Plate: in others the shell is covered by a thin outer crust of chalcedony, opake and hydrophanous; and the cavity is nearly full of very fine siliceous sand, over which in some places is a thin crust of flat botryoidal translucent chalcedony. M. Teignmouth. Min. Con.

C— cuneata. M. Pl. XVI. f. 19. Drawn from a specimen in Mr. Goodhall's collection.

Cyprina rostrata. M. Pl. XVII. f. 1.

Cytherea caperata. (*Venus.* Min. Con.) M., F. Variation in the depth of striæ. Min. Con. Blackdown, and near Lyme.

C— *lineolata.* (*Venus.* Min. Con.) M., Min. Con. Berehead. F.

C— *parva.* (*Venus.* Min. Con.) M., Min. Con. Pinhay? F.

C— *plana.* (*Venus.* Min. Con.) M., Min. Con. Pinhay? F.

C— subrotunda. M. Pl. XVII. f. 2.

Dentalium cylindricum. Near Exmouth. Min. Con.

D— *ellipticum.* F.

D— *medium* Pl. XVIII. f. 4. M., Min. Con.

Echinus, portion of an. Bere: In white calcareous sandstone. F.

Exogyra conica. (*Chama*, Min. Con.) M., F. Ware, west of Lyme Regis. Pinhay. Bere. F.

E— *conica*: var. Ridge high and sharp. Berehead. F.

E— *halyotoidea*? (*Chama*, Min. Con.) Blackdown. F.

E— *lævigata.* (*Chama*, Min. Con.) Lowest part of the green-sand at Berehead: In soft agglutinated sand, abounding in green particles. F.

E— *undata.* (*Chama*, Min. Con.) M. and Min. Con.

Fusus clathratus. M. Pl. XVIII. f. 19.

F— *quadratus.* (*Murex*, Min. Con.) M. Pl. XVIII. f. 17.

F— rusticus. M. Pl. XVIII. f. 18.

F— rigidus. M. Pl. XVIII. f. 16.

F— another species? M.

Gervillia aviculoides. M. Lyme. Min. Con., F.

G— *solenoides.* Min. Con.

Gryphæa canaliculata. (*Chama*, Min. Con.) M. Outer surface calcareous and effervescent, chalcedony within. F.

Gryphæa canaliculata: a broad variety. In yellowish effervescent sand, with green particles. F.

G— vesiculosa. Berehead ? M.

Hamites spinulosus. M.

Inoceramus concentricus. M. In iridescent chalcedony: Pinhay. In green hard stone. Min. Con., F. Near Lyme. D.

I— gryphæoides. M. Near Lyme Regis: In concretional masses of hard greenish grit, including very small scales of mica, and some minute black specks, under Dowland's Cliff. Miss Anning; and F.

I— sulcatus. Berehead. M.

Isocardia ? F.

Lima semisulcata. (*Plagiostoma semisulcatum.* Nelson.) M. Pl. XI. f. 10.

L—? subovalis. M. Pl. XVII. f. 21.

Littorina pungens. M. Pl. XVIII. f. 5.

L— gracilis. M. Pl. XVIII. f. 12.

Lucina ? orbicularis. M. Pl. XVI. f. 13.

L— Pisum. M. Pl. XVI. f. 14.

Lutraria striata. Pinhay near Lyme. Min. Con.

Mactra angulata. M. Pl. XVI. f. 9.

Modiola reversa. M. Pl. XVII. f. 13.

Murex Calcar. M., F. In iridescent chalcedony. Min. Con.

M— quadratus. (See *Fusus.*)

Mya læviuscula. M. Pl. XVI. f. 6.

M— mandibula. Pinhay Cliff. In firm green micaceous sparry grit. F.

M— plicata. (See *Panopæa.*)

Mytilus inæquivalvis. M. Pl. XVII. f. 16.

M— lanceolatus. Min. Con.

M— prælongus. Pl. XVII. f. 15.

M— tridens. M. Pl. XVII. f. 14.

Nassa costellata. M. ? Pl. XVIII. f. 26.

N— lineata. M. Pl. XVIII. f. 25.

Natica (Parkinson, Geol. Trans.). F.

N— ? carinata. M. Pl. XVIII. f. 8.

Natica granosa. M. Pl. XVIII. f. 7.

N— canaliculata. (*Ampullaria*, Geol. Suss.) M. Pl. XVIII. f. 6.

Nautilus elegans. M. Also in the sand near Lyme Regis. D.

Nucula angulata, M., F., Min. Con.

N— antiquata. M., F., Min. Con.

N— apiculata. F. Pl. XVII. f. 10.

N— impressa. M., F., Min. Con.

N— lineata. M. Pl. XVII. f. 9.

N— obtusa. M. Pl. XVII. f. 11.

N— pectinata. Pinhay. In hard greenish stone. F.

Ostrea carinata. M. Near Lyme Regis. D.

O— macroptera. Berehead. F.

Panopæa ovalis. M. Pl. XVI. f. 5.

P— plicata. (*Mya*, Min. Con.) M. Pinhay. F.

Pecten Stutchburiensis. M. Pl. XVIII. f. 1.

P— asper. M.

P— compositus. M. Pl. XVII. f. 20.

P— Millerii. M. Pl. XVII. f. 19.

P— orbicularis. M. Pinhay. F.

P— quadricostatus. M. A cast in grey chalcedonous chert. F. Haldon Hill, Devon. Min. Con.

P— quinquecostatus. Pinhay. F.

P—, (new.) Bere. F.

Pectunculus umbonatus. Blackdown. F. Haldon, Devon. Min. Con.

P— sublævis. Min. Con.

Perna rostrata. M. Pl. XVII. f. 17.

Petricola canaliculata. M. Pl. XVI. f. 11.

P— nuciformis. M. Pl. XVI. f. 10.

Phasianella pusilla. M. Pl. XVIII. f. 13.

P— formosa. M. Pl. XVIII. f. 14.

P— striata. M. Pl. XVIII. f. 15.

Pholas prisca. M. In silicified wood. The shell is chalcedony.

Pinna tetragona. M., Min. Con.

Podopsis striatus. M., F. Effervesces.

Pollicipes lævis. M. Pl. XVI. f. 1. (See also Pl. XI. f. 5.)

Psammobia? gracilis. M. Pl. XVI. fig. 12.
Pyrula Brightii. F. Pl. XVIII f. 21.
P— depressa. M. Pl. XVIII. f. 20.
Rostellaria calcarata. M., Min. Con.
R— macrostoma. M. Pl. XVIII. f. 23.
R— *Parkinsonii.* M., Min. Con., F., Pl. XVIII. f. 24.
R— retusa. M. Pl. XVIII. f. 22.
R— Another new species. F.
Scalaria pulchra. M. Pl. XVIII. f. 11.
Serpula ampullacea? M.
S— *antiquata.* M. Pinhay. Calcareous.
S— *carinella.* M. Min. Con.
S— filiformis. M. Pl. XVI. f. 2.
S— *plexus*? M. Effervescent.
S— tuba. M. Pl. XVI. f. 3.
S— vermes. Pl. XVI. F. f. 4.
Siphonia pyriformis (Goldfuss). Pl. XV. *a.*
Solarium conoideum. (*Cirrus plicatus*, M. C.) M.
Spatangus Bufo. (Goldfuss, Pl. XLVII. f. 7.) M.
S— Portion of another species, probably new. M.
Tellina inæqualis. Pinhay; M. Blackdown; Min. Con.
T— *striatula.* M. Pinhay; F. Blackdown; Min. Con.
Terebratula biplicata. M., F. Calcareous.
T— dilatata. M. Pl. XVIII. f. 2.
T— *dimidiata.* Haldon, Devon.; Min. Con.
T— *latissima.* (*T. lata*, Min. Con.) M.
T— megastrema. M. Pl. XVIII. f. 3.
T— *Pisum.* M., Min. Con.
T— *striatula.* M.
T— *Lyra.* M.
Thetis major. Blackdown. M. Berehead; Min. Con., F.
Thetis minor. Large. A cast in firm sparry grit. Pinhay, or Bere. F. Blackdown, and near Lyme. Min. Con.
T— (new.) Pinhay. A cast. F.
Tornatella? affinis. M. Pl. XVIII. f. 9.
Trigonia affinis. M., Min. Con. Blue mammillated chalcedony.
T— *alæformis.* Blackdown. M.:—Ridges very sharp. F. Near Lyme. D.
T— *dædalea.* M., Min. Con.
T— *eccentrica.* M. Hembury Fort, Devon. Min. Con.
T— *pennata.* Teignmouth. Min. Con.
T— quadrata. M. Pl. XVII. f. 12.
T— *spectabilis.* M., Min. Con.
T— *spinosa.* M., Min. Con. Near Lyme. D.
Turbo conicus. M., Min. Con.
T— *moniliferus.* M., Min. Con.
T— *rotundatus.* M., Min. Con.
Turrilites costatus. M. Not chalcedony.
Turritella costata. M., Min. Con.
T— *granulata.* M., Min. Con., F.
Venus angulata (see *Cyprina.*)
V— *caperata* (see *Cytherea.*)
V— *Faba.* F., Min. Con.
V— ? immersa. M. Pl. XVII. f. 6.
V— ? sublævis. M. Pl. XVII. f. 5.
V— *lineolata* (see *Cytherea.*)
V— ? *ovalis.* M., Min. Con., F.
V— *parva*, *V*— *plana* } (see *Cytherea.*)
V— ? truncata. M. Pl. XVII. f. 3.
V— ? submersa. Pinhay. F. Pl. XVII. f. 4.
V—. (Two other species; probably new.)
Vermetus concavus. Pl. XVIII. f. 10. Pinhay. Berehead. M.
V— *polygonalis.* Calcareous. Bere. F.
V— *radiatus.* (*Planorbis radiatus.* Min. Con.) M.

In addition to the species mentioned in this list, there are several others in Mr. Miller's collection, apparently new; but being too indistinct for figuring, they have been omitted.

(124.) *Blackdown to Shaftesbury.*—The great range of the chalk escarpment in the interior of England, which stretches, like the shore of a sea or lake, from Crewkerne in Dorsetshire to the north-east of Dunstable in Bedfordshire, is perfectly analogous in structure and appearance to the downs of Surrey and Sussex. It is interrupted by three or four indentations or gulfs;—one of great width, opening towards the west, between Crewkerne and the heights about Stour-head in South Wiltshire; another expanding to the north-west and terminating in the defile where the Thames cuts through the chalk, in its course to the south-east from Buckinghamshire and Oxfordshire. The vales of Pewsy and of Warminster are intermediate bays of the same general structure but of smaller dimensions; and all these valleys are apparently the result of denudation, aided by previous disturbance of the strata,—which has carried away the chalk, and laid bare to various depths the strata beneath it*.

The Green-sand hills range nearly from west to east for about ten miles on the south of Wellington and Taunton, and are then broken through irregularly, retiring towards the south to join the north-western extremity of the Dorsetshire chalk, of which some large outliers exist in the vicinity of Chard and Crewkerne. The chalk escarpment is thence continued in a direction parallel to the northern range of the Blackdown hills, to an opening on the north of Blandford, through which the Stour makes its way to the sea at Christchurch;—the tributary branches of that river, before it cuts through the chalk, winding extensively over the country around Sturminster, from whence the waters of the whole bay are conducted to the south-eastern coast. From the opening of the valley of the Stour the escarpment turns nearly north towards Shaftesbury, between which place, or rather between the prominence of the Upper green-sand on the north of it, and Mere, is the opening of the vale of Wardour. The beds immediately below the chalk from Crewkerne to Shaftesbury, have not yet been examined in detail, but the general distribution of the strata is represented in Mr. Greenough's Map.

South Wiltshire.

(125.) *Vale of Wardour.*—This tract may be considered as an eastern prolongation of the first of the great gulfs above mentioned, which being suddenly reduced in width between Shaftesbury and Mere, is continued east-

* The principles of structure in these tracts, are ably discussed in Dr. Buckland's well-known paper "On the Formation of Valleys, by Elevation of the Strata that inclose them," (Geol. Trans., 2nd Series, vol. ii. p. 119, &c.,)—where the vales of Wardour, Warminster, and Pewsy are expressly mentioned in illustration of the author's views.

ward as a valley surmounted on both sides by hills. It will be seen from the Map, Plate IX., that the anticlinal line by which this lower tract is traversed coincides in direction with that of the great Wealden denudation of Hants, Surrey, and Sussex; and is parallel also to the line of upthrow on the coast of Dorsetshire and the Isle of Wight, and to other shorter lines of elevation, the connexion of which is not at present visible, on the north of the Weald,—through Burgh-Clerc, Ham, Shalbourne, and Burbage, to the Vale of Pewsy. One of the anticlinal lines of the lower strata, beneath the new red sandstone, from Frome to the Steep Holm in the Bristol Channel also runs nearly from east to west; whilst, on the contrary, another line of fault by which the lower beds are intersected, beginning near Portishead-point on the west of Bristol, runs *northward,* across the Severn, through Newnham, and thence to the north-west of Gloucester *.

(126.) The Vale of Wardour has the general form of a triangle, the base of which extends from the chalk hills on the south of Shaftesbury to those of Mere, the apex being a little to the west of Harnham Hill on the south-east of Salisbury: for it is deserving of observation, that the stream of the Nadder escapes from this valley, not directly through the angle at its geological summit, but through the north side; in a manner perfectly analogous to that of the egress of the streams from the Wealden denudation in Kent and Sussex.

The heights which bound the vale consist at top of chalk, the inclination of which, like that of the strata beneath it, on the north of the anticlinal line, is in many cases more than 20°; while on the south, it is seldom more than 3° or 4°, apparently deviating but little from the general disposition of the strata in the South-east of England; and this anticlinal line itself is throughout much nearer to the north than to the south side of the vale. The strata from the chalk down to the gault inclusive seem to be continued all through, and to be nearly uniform in thickness; but the surface between the chalk hills is very irregular, and is divided by a ridge or bar formed by the escarpment of the Portland strata, on the east of which the ground is hilly, but on the west comparatively flat and low:—the appearances being altogether such as would arise from the deposition of the green-sands and chalk, over a tract partially occupied by the Purbeck and Portland forma-

* The anticlinal lines near Bristol, on the Map, Plate IX., are taken from Messrs. Buckland and Conybeare's paper on that district. For a full account of their relations to those in the South-east of England, the reader is referred to a paper since published by the Rev. W. Conybeare (London and Edinburgh Phil. Mag. for 1832, vol. i. p. 122, &c.), who states that one of the great lines of fault, by which the transition strata of the Quantock Hills in Somersetshire (beyond the range of the Map, Plate IX.,) are traversed, runs also nearly east and west.

tions, so as to overlie the latter, and beyond them come into immediate contact with the subjacent clays.

The small map, Plate VII. fig. 3, gives a plan of this valley on a larger scale than that of Plate IX., and the Sections AB to GH, Pl. X. a., No. 13., further illustrate its structure:—the strata being the *Chalk,—Upper green-sand,*—traces of the *Lower green-sand,* and of the upper members of the *Wealden*; beneath which the *Purbeck* and *Portland* formations are more fully disclosed.

(127.) *Chalk.*—The beds at Harnham Hill, immediately on the south of Salisbury, are inclined to the north ; and about a mile to the west of that hill a curved ridge, or horseshoe, formed of the upper chalk, seems to be the first divarication of the strata which bound the Vale of Wardour*. It therefore deserves inquiry whether the continuation of the fissure produced by an upheaving on the east of this point, may not be discoverable in the space between Salisbury and the head of the Wealden denudation. The southern limb of the chalk forms a continuous and lofty ridge from Harnham, through Compton Hill and Chiselbury, to White Sheet Hill, around the base of which the Upper green-sand occupies the whole space from Berwick St. John's to Shaftesbury, the escarpment of the latter formation, which is the immediate boundary of the vale, being continued all along the foot of the chalk range, and rising from beneath it towards the north.

On the summit of the ridge at Chiselbury, the chalk includes black flints in spongiform nodules: the Down slopes northward at an angle of upwards of 26° ; and at its foot there is a depression or trough. The lower and marly chalk form a ridge at Hoopside, about 200 feet above the stream at its base, and perhaps 100 below the summit of the highest range, which as the name indicates is curved, and nearly parallel to the curve of the upper chalk at the Race-course. The hill in Wilton Park belongs to the upper chalk, which there crosses the stream of the Nadder, passing through North Burcombe and thence towards the north of west, to form the higher downs, on the north of the valley, at some distance from the ridge of the sands. The lower chalk and chalk marl constitute an intermediate tract, in several places outtopped by the sand ridge. In the height above South Burcombe, is chalk with veins and nodules of flint ; and nearly on a level with the river, north-west of Hoopside, the Upper green-sand comes in.

The succession from the flinty chalk to the Upper green-sand, on the north of the valley, is well seen in the road from Hindon to Fonthill Gifford. The ridge on which the archway stands, at the entrance to Fonthill Park, being chalk with large flint nodules, exposed in a pit immediately without the plantations, dipping north about 12°, and separated by a depression from the ridge of the Upper green-sand, which is here very low.

* The Map, Plate VII. fig. 3, unfortunately, was engraved before I had observed the structure described in the text, so that the points here referred to are not included in it : but the features are well represented in the Ordnance Map; the aid of which, indeed, is almost necessary throughout these pages, to understand what is stated respecting the structure of the country.

(128.) *Upper Green-sand.*—The effect of the unequal inclination of the two sides of the valley is remarkably shown by the great difference in the extent of the spaces occupied by this formation. On the south, the upper beds are concealed at the foot of the chalk hills; but the lower strata shoot out into plateaus, which form the tops of the hills all the way to Shaftesbury; but on the north the whole series of the Upper green-sand rises abruptly and forms a very narrow ridge of unequal height. The Map and Sections, Plates VII. fig. 3. and X. a., No. 13., sufficiently explain this structure.

Some of the best sections of the transition from the chalk into the Upper green-sand are visible near Barford St. Martin and thence to Baverstock. In the lane over Baverstock Hill (called in the country Cloudles) the series consists of alternate beds of chalk and sand with green particles, succeeded by a thick bed of green-sand abounding remarkably in *Gryphæa vesiculosa*, which can be traced almost entirely round the valley. The ridge of these sands over Dinton House is full 200 feet above the bottom of the depression between it and the lowest chalk.

The greatest superficial extent of this formation occurs in the vicinity of Shaftesbury, where the upper part seems to have been better preserved than in the continuation of it eastward. The sections vary from 50 to 60 feet in thickness; of which about a third at top contains beds of chert like those of the Isle of Wight: but the lower beds only are found in the plateaus which project beyond the chalk.

Several good sections of the upper strata are visible in the lanes about Shaftesbury;—at Ludwell, Hernsham Street, in the ascent from Brookwater, and thence to the foot of White Sheet Hill, where some of the quarries include chert and veins of chalcedony.

From Castleditches,—an ancient fort or encampment on the summit of a remarkable prominence, the sand which composes the top declines uniformly towards the foot of the chalk range, but extends with an even surface, westward to Shaftesbury, and eastward to Barford Heath. The beds have many points of general resemblance to the sands of Blackdown;—with this important difference, that a very distinct stratum of bluish clay (Gault), which is wanting at Blackdown, is here found, everywhere, below the sand.

The relations of these strata are well shown in a large quarry at the top of the hill east of the valley of Fovant and of the Pembroke Arms, where the following was the order:—

Fovant Quarry.

	Ft.	In.
Soil and Grass.		
1. Greenish sand, alternating with gray, including stone which passes into chert, in irregular concretional bands and masses:—very like the sands of Blackdown .... 14 to	16	0
2. Sand of a much darker hue, below passing into stone.....about	5	6
3. Stone called "Greenstone", in firm beds, which are quarried for building; upper surface irregular; contains *Gryphæa vesiculosa*, Pectens, and shark's teeth .....about	9	0
This stone is valuable from its not being affected by frost. It can therefore be dug at any season, and stands well in water, as the foundations of bridges, and in exposed situations, as in copings, &c.		
4. Stone; but not good	1	6
5. Sand; depth unknown.		

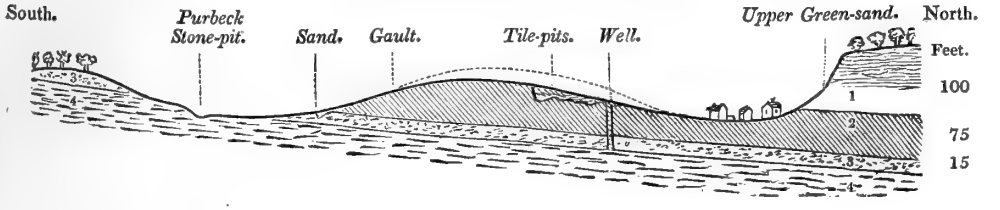
On the north of the valley, the Upper green-sand appears likewise to consist of two portions;

that which immediately succeeds the chalk, the equivalent of the fire-stone of Surrey, and the Malm-rock of Western Sussex, abounding in chert. To the lower portion the term Green-sand is strictly applicable, as it is composed of sand, and abounds in green particles.

About two miles west of Ridge the sands suddenly expand and occupy a large space from the north of Fonthill Abbey to Stop Beacon, where the surface is strewed with fragments of chert, the remains, probably, of the higher beds which have disappeared. But further west, between the Abbey and East Knoyle through Middlemore, the ridge again is narrow and highly inclined; but so much reduced in height, that the chalk of Hindon can be seen over it from the flat country at the mouth of the vale. The sands again expand a little on the west of East Knoyle; but at Upton their dip is not much less than 40°; so that the horizontal section occupies but a few paces, and on the north the chalk is seen at a lower level, connected by insensible gradation with the sands.

(129.) *Gault.*—The clay beneath the Upper green-sand seems to be co-extensive with that formation. It forms on the south of the Vale of Wardour a rapid slope; on the north, a depression, immediately below the sand; and is identified in several places with the gault of the eastern counties by the characteristic fossils. At Lower Donhead, under Lidhurst, it contains Ammonites with coproid masses of phosphate of lime; and at Ridge, where one of the most distinct sections is exposed, many other fossils have been found, the clay having been long used for tile-making. The beds all dip to the north, between 6° and 7°; and a well has been sunk through the clay, and a thin bed of sand beneath it, down to the Purbeck strata; the order being thus:—

Section at the Tile-pits, Ridge.



	Ft.	In.
1. *Upper Green-sand*, at the upper part of the hill, consisting of—		
a. Green-sand.		
b. Green sand-stone, full of *Gryphæa vesiculosa* at the upper part.....8 to 10 ft.		
c. Greenish sand.....more than 30		
d. A bed called by the workmen "malm-rock"; sand with stems of Siphonia and impressions of Ammonites.....about 60		
	100	0
2. *Gault*, including near the top a bed of pyrites, shot through with veins of calcareous spar, of which some large crystals are found here. The rest is clay* containing Ammonites, and other characteristic fossils, with Septaria and ovoid concretional masses of phosphate of lime.....	75	0

* About 3 feet of clay, which occurs on the north-west of Ladydown, may belong either to this stratum, or to one of the beds subordinate to the Purbeck formation.

3. Sand; (perhaps the representative of the Lower green-sand) said to be like that of the hill top. Masses of a calcareous conglomerate in the upper part ..... } 15 0

4. Fissile stone; some of the upper beds of the Purbeck series:—

   a. Slaty limestone, abounding in Cypris and Cyclas, with smooth Paludinæ, and another acute spiral univalve.

   b. Fine-grained oolite in uniform globular particles, like the roe of fishes.

(130.) *Lower Green-sand.*—This formation is nowhere prominent in the Vale of Wardour, and scarcely observable throughout the greater part of it. The ferruginous sands below the gault in the eastern portion of the valley may not improbably be referable to some of the Wealden sands; but on the road descending from the Pembroke Arms to Catherine Ford, a bed of greenish sand occurs below the gault, which seems to be superior to the Wealden strata; and if this be continuous with a bed of sand which appears at Penthurst and Fovant, it must belong to the marine beds; as I found at the former place a Pecten and the stem of a Siphonia. Ochreous sand, with some blue clay, to a total thickness of five or six feet, occurs likewise above the Purbeck strata at Totterdale (*Totteridge* of the Ordnance Map),—a height on the south of Tisbury, to which I shall hereafter have occasion to refer. On the north side of the valley, sand of the same doubtful character occurs immediately below the gault; but a bright ochreous clay, in a corresponding place between Apsell and Chicksgrove, is in my notes referred distinctly to the Lower green-sand; and a part of the sands from Fonthill Abbey to Stop Beacon, may also belong to the same formation. On the whole, however, the difference between the bulk of the Lower green-sand here, from that which it exhibits in Kent, Sussex, and the Isle of Wight, is very remarkable, and accords with the rapid thinning out of the formation westwards, on the coast of Dorsetshire and Devon.

(131.) *Wealden.*—The indications of the upper members of this group in the Vale of Wardour are likewise indistinct, nor did I find here any of their fossils; but where the strata rise slowly from beneath the gault on the east, under Fovant Wood, and thence by Catherine Ford and the sloping ground towards Dinton and Teffont Magna, (Pl. VII. fig. 3; and Pl. X. a., No. 13.,) are traces, probably, of the Weald clay and Hastings sands; the pond at Dinton Parsonage, especially, resting on a bed which answers well to the site of the Weald clay. These indications deserve notice, as they furnish the only instance with which I am yet acquainted, of the occurrence of the upper members of the Wealden in the interior of England. The place where these strata may be looked for with the greatest chance of success, is on the descent from the plateau of the Upper green-sand to Catherine

Ford; and their existence is rendered more probable, by the distinctness with which the connected strata of the Purbeck group are developed; the whole series apparently thinning out towards the west.

(132.) *Purbeck Formation.*—The Purbeck beds rise from beneath the sand and clay at Dallard's Farm, near the eastern angle of the Vale of Wardour; and from that point they can be traced,—on the south of the Nadder, at least as far as Totterdale, south of Tisbury; and on the north, to Ashley Wood, west of Ladydown, or perhaps to Stop Street, a hamlet above the village of Fonthill Giffard; occupying also the greatest part of the intermediate heights between these extreme points. The strata throughout agree with those of the coast; their fossils, with the exception principally of oysters, belonging to freshwater genera; and at the lower part near their junction with the Portland stone, they likewise include beds of clay alternating with limestone; one of which at least contains the trunks of silicified trees. The abundance of marine shells in the Portland beds immediately below, is here as remarkable as in the Isle of Portland.

The Map and Sections, Pl. VII. fig. 3., and Pl. X. a., fig. 13. A B &c., show the general relations of the Purbeck series. The principal quarries open, in the upper part of this formation, when I examined the country, were at Dallard's Farm above mentioned; at Dashlet on the south of the Nadder, about midway between Catherine Ford and Chicksgrove; and on the opposite bank of the river, at Teffont Evias and near Legh-barn. The junction of the Purbeck and Portland strata was best seen in a quarry at Wockley, on the south-east of Tisbury, the counterpart of a much larger one, worked some years ago at Chicksgrove (or Chilmark) Mill, but now obscured by decomposition from long exposure.

At *Dallard's Farm*, the beds first seen, on the west of the upper green-sand and gault, were thus:—

	Ft.	In.	Ft.	In.
1. Soil and Grass.				
2. Yellowish brown ferruginous loam, or clay			1	6
3. Slaty stone and clay, including seams of fibrous carbonate of lime:				
a. Slaty limestone, containing *Ostrea distorta*, Pl. XXII. fig. 2.	0	6		
b. Fissile whitish calciferous clay, called "Spangle" by the quarrymen, including great numbers of a small Modiola	0	6		
c. Whitish uniform limestone, including *Corbula alata*, Pl. XXI. fig. 5., like that near the coast at Upway	0	9		
d. Fissile clay	1	0		
e. Clay; somewhat like *d*, but more approaching to stone	0	6		
f. Fissile clay, like "Spangle", with Modiolæ, like those of *b.*	1	0		
			4	6

	Ft. In.	Ft. In.
4. Slaty limestone in firm beds, alternating with blue fissile clay:		
a. Rough and irregular above ..... 6 in. to	0 9	
b. Stone; firm and durable, abounding in Cyclades;—within the valves of which are deposited beautiful casts of a small species of Cypris. See Pl. XXI. fig. 7 *b.*	1 3	
		2 0
5. Alternations of very blue fissile clay, with thick slaty stone, containing *Ostrea distorta*		1 6
6. Stone; continued downwards ..... visible		2 0

These lower beds are of different tints of blue and gray; the gray by exposure becoming white, and the blue portions graduating into a hard, somewhat splintery stone, which in some specimens might be taken for limestone of the carboniferous series; some of the slaty strata alternating with clay (3 above), consist of worn, rounded, fragments of shell and of stone, and are very like some of the upper beds of Bermuda. The outer surface of the more uniform limestones is here much eroded by the weather; and when the masses are split, the natural partings are frequently found to be furrowed or eroded with tortuous irregular channels, from half an inch downward in diameter.

The pits along the south bank of the river, where the Purbeck series emerges from beneath the heights of sand, afford several good sections;—very much alike, and fairly represented by the following detail of one at *Dashlet*. (See the Map, Pl. VII. fig. 3.)

Section of the Stone-pits at Dashlet.

	Ft. In.	Ft. In.
1. Brown, loam-like clay, including, or passing into 2.		1 0
2. Concretional, but nearly continuous masses of soft stone, with layers of Cyclades and Cypris, and oolitic particles ..... about		0 6
The oolitic particles, when decomposed, leave empty cavities in the firmer cement, which might be mistaken for casts of Cypris.		
3. Fissile stone, in irregular beds, almost entirely composed of Cyclades and Cypris		1 3
4. A group of clay and limestone:		
a. Thin slaty, calciferous clay, including *b.*	0 3	
b. Delicately fibrous carbonate of lime, with impressions of *Cyclas media* on the surfaces adjoining the clay; the beaks unusually sharp	0 2	
c. Clay	0 1	
d. Flattened roundish masses of uniform white and gray stone, imbedded in the clay of *c.* and *d.*; vertical cracks within, as in Septaria	0 4	
e. Brownish clay ..... 1 in. to	0 2	
f. Fibrous carbonate of lime	0 1	
g. Fissile clay, calciferous below ..... 1 in. to	0 6	
		1 3 to 1 6
5. Compact limestone, in some places bluish, containing very large Cyclades (*C. major*); a large flat bivalve (Unio?); small bones and palates of fishes; and fragments of *Ostrea distorta*, Pl. XXII. fig. 2.		1 4 to 1 6

The slaty limestone in the pits hereabouts affords the same beautiful casts of Cypris as are found at Dallard's, frequently inclosed within the valves of Cyclades, of which, in fact, the beds are almost entirely composed. In other cases the surfaces of the strata are covered with impressions of a small Modiola. The clay is often divisible into fragments, which are polished, as if by friction under strong pressure.

Some of the beds of uniform whitish limestone, to which the workmen give the name of "Lias", very much resemble the stone of Monte Bolca; and where most compact, are so like the stone used in lithography, that their application to that purpose seems to be well deserving of trial. The exposed edges of the thicker folia are eroded deeply into spongiform cavities. In some of the pits, the limestone, alternating with clay, has the appearance of united concretions or lumps; but within the stone is uniform, the aspect that of freshwater limestone, and the fracture splintery or very flat conchoidal, resembling a rock found in a corresponding place at Garsington near Oxford, which is there called "Malm". The masses split into irregular flakes at right angles to the surfaces, not more than a twentieth to an eighth of an inch thick. Both the clays and limestones in this part of the Purbeck series have sometimes a bluish colour; and both inclose large specimens of *Ostrea distorta*.

On the north side of the valley, as the Purbeck strata rise more rapidly, the sections are not so much expanded; but about Teffont Evias slaty limestone, alternating with clay and fibrous carbonate of lime, is seen not far from the gault, dipping about north 15° west, at an inclination between 2° and 4°. A thick coating of these strata invests the heights thence to Ladydown, (see the section, Pl. X. a., fig. 13. AB.); but about midway to that place, it is cut through by a natural ravine, which runs from Chilmark to the Nadder at Penthurst Bridge, and not improbably may have originated in a dislocation. The Portland beds which form the lower part of the ravine have been extensively quarried on both sides.

At Ladydown, near the highest ground occupied by the Purbeck formation, quarries have long been worked to great extent, chiefly for the sake of the fissile cycladiferous stone, like that of the Isle of Purbeck, which here bears the name of "Tilestone". Among these beds is a group which abounds in the remains of fishes.

On the south of the Nadder, near Benston, a prominence, like a step at a lower level, extends beyond the sands and clay which form the upper part of the hills, and is continued to Wockley and the west of Anstey Water, capping the height occupied by Totterdale Farm, where the Purbeck beds run out. In the lower part of this projection, a large quarry was for many years worked at Chicksgrove Mill, and another more recently at Wockley; the bottom of the former is nearly level with the river; the top about 50 feet above it, and about 30 feet lower than the top of the prominence above mentioned. The total thickness of the Purbeck strata indicated by these data does not exceed 60 feet.

A few beds occur in the upper part of the section at Chicksgrove, which do not remain at Wockley; but the rest are so nearly the same at the two places as not to require a separate detail.

List of the Beds at Chicksgrove Mill, and Wockley Quarries.

	Ft.	In.	Ft.	In.
Chicksgrove.—				
Grass and soil ..... about	0	9		
1. Loam; including fragments of stone, like the "*lias*" of the pits above mentioned ..... about	1	3		
2. Bluish clay, passing into 3. ..... 3 in. to 6 in.	0	5		
3. Yellowish brown, tough clay, very uneven at the bottom; filling up the irregularities of 4 ..... 3 in. to 9 in.	0	6		
4. A bed of coarse, somewhat gritty limestone, very irregular in thickness, but nearly continuous; in many places having the aspect of magnesian limestone, and containing nests of carbonate of lime in rhombic crystals..... 1 ft. to 3 ft.	2	0		
			5	0

	Ft. In.	Ft. In.
5. A bed, likewise very irregular, consisting of—		
a. Brownish clay, at the upper part.		
b. Cavernous concretions or crusts of carbonate of lime, in the form of irregular flakes; which in some places have a deceptive appearance of organic structure. This bed accommodates itself to the inequalities in the surface, both of 4 above and of 5 below it; and seems to be a mass of loose loamy clay, shot through by stalagmitic carbonate of lime.....		
6. A bed much decomposed, and very unequal in thickness: apparently consisting of soft, calciferous clay, with some portions of firmer limestone		
All the preceding beds seem to be above those of the Wockley Quarry.		
7. (Apparently the same with 2. and 3. of Wockley.) Irregular portions of limestone, very indistinct from decomposition; sometimes wholly wanting; sometimes in the form of thin slaty beds waving over the inequalities of the clay (8.) below ... . 1 ft. to 1 ft. 6 in.	1 3	
The whole thickness from 4ft. to 7ft. inclusive is .....about		6 0
8. Tough clay, (seems to be the same with 4. of Wockley).		
Wockley.—		
Grassy surface.		
1. Ferruginous loam and sand, filling the irregularities in the top of 2.....6 in. to		1 0
2. Compact limestone, much decomposed, but in the fresher pieces mottled, grey and bluish. At the bottom this bed is divisible into flakes or thin strata, curved, or waving; very like the lower part of the "slate" of Portland, and the fissile beds above the Portland stone at Bacon Hall, (p. 223.) (*Quæ.* the "Soft Burr," or "Bacon-ledge"). ..... 1 ft. 6 in. to 2 ft.		1 9
3. Decomposed whitish, fissile limestone; passing at the lowest part into 4., and very nearly resembling the "Cap" at Bacon Hall ..... about		2 6
4. (8. of Chicksgrove Quarry.) Tough dark clay, in some places very like Fuller's-earth: seems to represent one of the "dirt beds" of Portland and the coast near Lulworth, but is more uniform, and does not contain fragments of stone		
5. (9. of Chicksgrove.) Fissile stone and clay.		
a. Hard stone.....	0 5	
b. Thin slaty stone, in some places sandy, abounding in casts of Cypris, and in *Cyclas elongata*, Pl. XXI. fig. 9. This bed very much resembles the decomposing "Cap" of Upway (p. 223.) and may perhaps correspond to the "*Ash*" of Portland (p. 220.)	1 3	
The beds of this part of the section, at Chicksgrove, include also a minute spiral univalve. They are intersected by veins of stalactitic carbonate of lime, like those in the "Cap", &c., of Portland.		
c. Fissile calcareous matter, in beds of unequal thickness, curved at the lower part over the masses of *d.*; precisely like the bottom of the "Cap" at Bacon Hall, (p. 223.)	0 10	
d. Irregular concretional masses of black flint, rugged without when detached; not in themselves distinguishable from chalk flints		2 6
6. (10. of the Chicksgrove section.) Fissile, somewhat gritty limestone; at top enveloping the flinty masses 5. *d.*; below adhering to 7. This bed at the upper part contains casts of Cypris in great numbers. The proprietor of Chicksgrove Quarry told me that fishes, like those of Ladydown, were found in this part of the series, both there and at Wockley; but the specimens which I could obtain were much smaller than those of that place.....		

	Ft.	In.	Ft.	In.
7. (11. of Chicksgrove.) Uniform, soft, very white limestone, here called "chalk"; but abounding at the upper part in Portland fossils: *Pecten lamellosus, Cardium dissimile, Trigonia gibbosa, Ostrea expansa.* This bed is not fit for building, and is burnt into lime: it seems, nevertheless, to represent the "white-bed" of Portland, though without oolitic structure				
8. (12., &c., of Chicksgrove.) From 7. to the bottom of the quarry, a depth of about 25 feet, in 8 or 9 beds, is called "Freestone": the detail as follows:—				
a. Whitish stone, called "chalk", of uneven, subconchoidal fracture; containing great numbers of *Pecten lamellosus* and Cytherea	2	0		
b. Cream-coloured, somewhat sandy stone, also with *Pecten lamellosus*	2	6		
c. Similar stone; *Trigonia gibbosa*, Cytherea, *Pecten lamellosus.* Sometimes this bed includes 5 to 8 inches of sand .....2 ft. to	3	6		
d. Concretional stone and sand.				
i. Stone ..... 0 0 to 1 8				
ii. Sand, separating and surrounding the concretions of i. 4 0 to 2 6				
about			4	0
e. Stone and sand:—				
i. Concretional stone ..... 1 0 to 3 0				
ii. Sand around the concretions..... 2 6 to 0 6	3	6		
f. Stone	4	0		
g. Ditto	3	6		
h. Ditto	2	0		
			25	0

These lower beds (which afford the best stone) contain *Ammonites giganteus* of great size: they are more like the form of the Portland stone which occurs in the Isle of Purbeck than that of Portland Isle itself.

Bottom of the Quarry.

At a new quarry near Chicksgrove Mill, the dip was east 25° south, at an angle of 2° or 3°.

(133.) *Junction of the Purbeck and Portland formations.*—It is obvious that the preceding strata, down to 7, represent the lower part of the Purbeck series, which in the Island of Portland includes the petrified trees and Cycadeæ; and the section here is valuable, as it exhibits some variation in the form of those lacustrine deposits. One of the principal points of difference between the sections at the two places is, that the freshwater strata here rest, immediately, upon a bed containing marine fossils, without the intervention of any clay or dirt. Another difference is, that no flinty masses are found here, at the top of the Portland formation, like those immediately above the white bed in the Isle of Portland; but, on the contrary, a range of irregular masses of black flint occurs distinctly within the *freshwater series*, and is separated from the Portland stone (No. 7. of the preceding list) by a bed of freshwater limestone (No. 6.), including casts of Cypris. As the flint, in this latter case, does not contain fossils, its presence immediately above the junction, while it is wanting in the usual place below, might at first sight mislead: but the occurrence of flinty masses is by no means unfrequent in other parts of the Purbeck group; and in the quarries north of the Nadder, opposite to

Dashlet above mentioned, where some of the beds partially composed of dark-coloured flint, are full of Cyclades and other freshwater fossils.

(134.) *Petrified Trees.*—I saw no traces of trees or Cycadeæ either at Chicksgrove or Wockley, nor could I learn that any specimens had been found there; but I had the satisfaction of finding, on the road from Totterdale towards Walmead*, at a point nearly on a level with the top of the quarry at Wockley, several fragments of a silicified coniferous trunk, with cavities encrusted with quartz crystals, as in Portland and the Boulonnois†, which had obviously come from a stone-pit just then filled up, on the road-side: and soon afterwards, the workman who had dug them out informed me, without being asked a question, that all the fragments were portions of one large mass, "thicker than a man's thigh," which, he said, stood upright among the strata, "*like a gatepost*,—and did not lie flat like the beds "of stone. He had quarried," he said, "many a piece near this place, "as much as a man could heave up, and all standing upright." This testimony leaves no doubt that trunks in the erect position have been found here, —precisely in the geological place where they might have been expected; and it is highly probable that further examination will lead to their discovery *in situ*.

A bed or beds, of clay, near the junction of the two formations, in which silicified trees may be expected, comes to the surface at several points along the river, between Ham Cross and Ashley Wood on the west of the Ladydown Quarries. In one place on this line, at a streamlet which crosses the road from Chicksgrove to Ham Cross, a bed or beds of clay, apparently belonging to the upper part of the Chicksgrove section, comes down to the level of the road, and well deserves to be examined; and on the descent from Totterdale, above mentioned, towards Anstey Water, is another spot where fossil trunks might be sought for with great probability of success.

(135.) *Portland Strata.*—The general disposition of the Portland beds in the Vale of Wardour will be understood from the map and sections, Pl. VII. fig. 3., and Pl. X. a., No. 13. AB &c. The upper strata are best seen in the sections at Chicksgrove, Wockley, and Chilmark.

The stone is found in the bed of the river at Chicksgrove Mill, and continued without interruption on the south of the valley, beneath a covering of the lowest Purbeck strata, which cap the height at Totterdale, to the vicinity of Wardour-castle, beyond Bridsor. On the opposite side of the river the strata soon begin to dip towards the north; but they rise also slowly west-

* The names in the Ordnance Map here require correction. The word Totteridge ought to be *Totterdale*, and should be transferred to the present place of the word *Highgrove*; the former being the name of the farm.

† Some of the specimens from this place, of a brownish hue, were found by Dr. Prout to consist almost wholly of silex, with slight traces of bituminous matter.

ward, to their final disappearance near Pyt-house. The remoter portions of this formation, on the north-west, form some of the highest ground within the surrounding ranges of green-sand,—as at Higher Lawn, Newtown, Pythouse, Linley, and Summerleaze; rising at the first two of these places, nearly as high as the summit of Stop-Beacon, and out-topping the chalk immediately on the north of the valley. The hill at Newtown is higher than the top of Castleditches.

The disposition of the beds on both sides of the Nadder westward, accords with that in the eastern portion of the valley; the dip at Chicksgrove Mill being about east 25° south; and at an old quarry near the syllable *-ton* in the word *Hazelton* of the Ordnance Map, south about 40° east. On the south of the road from Newtown, immediately below the letters *ho* in the word *Pythouse*, the dip is likewise nearly south, at an angle of about 22°, but this rapid inclination may be, in part, the result of subsidence. On the north of the anticlinal line the beds dip rapidly in an opposite direction. Thus, at Linley on the west of Lower Lawn and Summerleaze, and on the north of Ashley Wood east of the line of Ponds, where the Portland strata come very near to the ridge of Upper green-sand, the dip is almost directly north. In a quarry west of the road from Tisbury to Fonthill, it is north 30° east, at an angle of about 20°, and the beds are much shattered by fissures.

Excellent sections of the upper Portland beds are displayed in the quarries on the ravine between the village of Chilmark and Penthurst Bridge (See Pl. X. a., No. 13, line A B.); where the strata are inclined to the east 10° south, between 3° and 4°. Among the loose matter at the top of these quarries is botryoidal carbonate of lime, passing into compact freshwater limestone, —like the "Cap" of Portland, and the stone called "malm", at Garsington in Oxfordshire. The uppermost Portland beds here afford beautiful specimens of a fine-grained oolite like that of the "roche" in Portland: but the stone in some places alternates with sand, and has, in general, a very sandy character.

The principal quarries of the Vale of Wardour are in the vicinity of Tisbury; and some of the best, when I was in the country, were near the road from that village to Fonthill Gifford. The stone is more like that of this formation in the Isle of Purbeck, than in Portland itself, and of a darker hue. A continuous bed of flint, about 2 inches thick, in one of these quarries (Bevis's) had supplied, I was informed, the beautiful specimens of corals in chalcedony, which are found in collections from this part of England. Among the fossils I obtained at Tisbury are *Astarte cuneata*, *Ammonites biplex* in chalcedonic flint; *Ammonites giganteus* of great size, *Nerita sinuosa*, *Terebra Portlandica*, *Turritella excavata* (*Cerithium? excavatum*). A full enumeration of the species found here, and generally of the fossils of the Vale of Wardour, was drawn up by Miss Benett for Sir R. Colt Hoare's History of Wiltshire; separate copies of which, illustrated by plates of some of the new species, have been presented by that lady to her friends *.

The continuity of the strata hereabouts is frequently interrupted by chasms, locally called "lets", like those of Portland (*supra*, p. 218.) and of Oxfordshire; in which the beds are abruptly broken off, and the intervals filled with rubble and looser materials, to a perfectly level surface, covered with a uniform coat of vegetable soil.

Portland Sand.—I saw no place in the Vale of Wardour in which the beds immediately beneath the Portland stone were exposed; but I believe that the Portland sand occupies a great part of the descent from Pythouse to the plain on the west of it; and in crossing from Newtown to Hazelton this group seems to be disclosed immediately below the latter village, springs breaking out along the line of contact. If this be correct, the bluish gray strata, occasionally visible in the

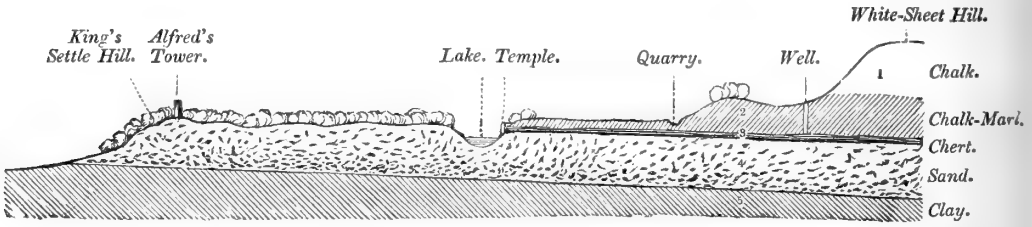
* "A Catalogue of the Organic Remains of the County of Wilts," 4to, Warminster, 1831.

streams on the north and east of that point, must be referred to the Portland sand; which, therefore, seems here to be more like that of the coast than of Oxfordshire and Bucks. At Tisbury, I was informed, sand is found, but not more than 18 inches thick, beneath the lowest beds of the Portland stone.

Kimmeridge Clay.—The whole of the level tract on the west of the opening of the vale seems to be occupied by clay; and this I have referred to that of Kimmeridge, on the following grounds, which, it must be acknowledged, are not very satisfactory. The gault and this clay come into contact, on the north of Shaftesbury, and beneath the heights of green-sand at East and West Knoyle,—in consequence of an overlapping of the whole cretaceous group, analogous to what is observable in Devonshire. The lower clay, which is used for brick-making on the west of Shaftesbury, contains *Panopæa depressa*, and casts of Ammonites like those of Kimmeridge, with other fossils, and includes a band of Septaria, there called "Turtle-stone". I myself found a Pullastra? about a mile south-west of Pythouse, at the brick-field of Great Mead (or Moat) on the north of Semley; and Miss Benett states that clay with the Kimmeridge fossils occurs at Binley Farm (*Quæ.* Linley of the Ordnance Map?), on the west of Pythouse. I did not hear of any bed of stone between the heights of Shaftesbury and Knoyle. It is not, however, improbable, that outliers of the gault or Upper green-sand may exist within that tract. But whether the Oxford clay also does not occur in the remoter part of the low country on the west of the escarpment,—the Oxford oolite as well as the Portland strata being wanting there,—I could not ascertain.

(136.) *Stourhead.*—I regret that it was not in my power to examine the heights on the west of Mere, which, according to Mr. Greenough's Map, consist of the green-sands projecting beyond the chalk escarpment; since, from the information of a friend, to whom I am indebted for the subjoined sketch and list of the strata, the Lower green-sand may be more conspicuous there than on the confines of the Vale of Wardour; which would prove that this group, like the Upper sand, is alternately expanded and again reduced in bulk and development.

The subjoined section extends from the chalk on the east of Stourhead, to the clay beneath the hill on which Alfred's Tower is placed, which is said to be 817 feet above the sea.



1. Represents the Upper *Chalk*. Feet.
2. *Chalk Marl*, here called "Malm". In this a well had been sunk, which afforded the following strata, by report of the well-sinker:—
   - *a.* "Malm"; like the chalk-marl of Lewes in Sussex, full of the characteristic fossils: sharks' teeth in great abundance 100
   - *b.* "White Stone"; so called, but in reality rather gray or green: full of Ammonites, many of which preserve their iridescent coats 4

Feet.

3. *c.* "Chert". At the lower part rubbly; and there the water rose 30
This stratum is visible in immediate contact with the sand (4.), above the Temple, on the brow overhanging the lake.

4. *Sand*; constituting the whole of the elevated platform on which Stourhead House is placed, and extending westward about two miles, to Alfred's Tower. It is a loose sand, with huge concretional masses of stone of similar composition. [*Quæ.* the "cowstones" of the Devonshire coast?] Fossils are abundant in the upper beds: the lower are more ferruginous.

5. *Clay*; probably that of Kimmeridge?.—(or Gault?)

From a comparison of this list, with the sections in the Vale of Wardour, of which the beds here represented are a prolongation, I should have been disposed, but for the opinion of my correspondent, to regard the series as coinciding with that of Ticklepath Hill (Pl. X. a., No. 13., line G H), and East Knoyle: the *Lower* green-sand being indistinct or wanting;—which is probable from the absence of gault between the "chert" (3.), and the sand below it. In this case, the gault would be inferior to the sand (4.), and perhaps a portion of the "clay" (5.). If the clay be exclusively that of Kimmeridge, the gault must be looked for above; and a part of (4.) might then represent the Lower green-sand, which, we shall find, occurs distinctly in the vicinity of Devizes, about twenty miles from this place.

(137.) *Vale of Warminster.*—The relations of the strata here are shown in the section, Pl. X. a., No. 14., on a line nearly from north to south. The denudation in this valley having cut less deeply than in the Vale of Wardour, the Gault is the lowest bed brought into view; and this only in the deeper parts of the streamlets. Excellent sections of the *Upper green-sand* are visible around the town of Warminster; the beds which contain chert being, in all cases, near the top, and the lower part almost pure gray or greenish sand.

The *Gault*, at Crockerton, is a somewhat micaceous bluish clay, affording many of the characteristic fossils; and along with these Miss Benett has obtained masses of a gum or resin, supposed to resemble that found in the London-clay at Highgate, which has obtained the name of Fossil Copal*. I refer to the subjoined list, for the fossils which I myself obtained here; and to Miss Benett's Catalogue already quoted, and that annexed to Mr. Lonsdale's paper hereafter mentioned†, for a much more complete enumeration.

(138.) *List of Fossils of the Vales of Wardour and Warminster, in South Wiltshire.*

[*Upper Green-sand.*]

Ammonites monile. Vale of Wardour, at the contact of the Upper green-sand and the gault; in conglomerate of green-sand.

A———— varians. Ridge; in a compact fine-grained rock, approaching to what is called "marlstone" at Dean's Farm, west of Farnham in Surrey (page 150, line 10, &c.). East Knoyle, between Upton and Chapel Farm, in the lowest chalk.

* Aikin's Manual of Mineralogy, 2nd edition, p. 44.; W. Phillips's Mineralogy, 3rd edition.

† Geol. Trans., Second Series, vol. iii. p. 276.

Exogyra conica. In great abundance. Vale of Wardour: Castleditches Hill: Norton Bavant; and Hernsham Street. Vale of Warminster.

Gryphæa vesiculosa. Vale of Wardour: between the Bull Inn and Sutton Mandeville; between Barford Street and Baverstock Church; Castleditches; Fovant, lowest beds; Ridge; Dinton, upon *Turritella granulata*?.

Inoceramus? Between Upton and Chapel Farm. East Knoyle; in the lowest chalk, with green particles.

Natica? In green-sand rock; somewhat slaty: Fovant? or Teffont.

Ostrea. Between the Bell Inn, and Sutton Mandeville.

Pecten orbicularis. Vale of Wardour: Hernsham Street; Fovant Quarry: Castleditches?

P—— quadricostatus. Vale of Wardour: Hernsham Street, in soft green sandrock.

Spatangus Bucardium? (Goldf., Tab. 49, f. 1.) Vale of Warminster.

S——— granulosus? (Goldf., Tab. 45. f. 3.) Vale of Warminster.

Turritella granulata? Vale of Wardour: Dinton.

Vermetus umbonatus. Ridge.

[*Gault.*]

Ammonites auritus. Vale of Warminster: Crockerton?

A——— Benettiæ. Vale of Warminster. Crockerton. A large specimen surrounded with branched vermicular stems, composed of greenish sandy shale: preserving its iridescence.

A——— Beudantii. Vale of Wardour: Ridge.

A——— dentatus. Ridge; with nodules of phosphate of lime. Crockerton; in a mass composed of phosphate of lime.

A—— new: allied to *dentatus.* Crockerton.

A——— lautus. Crockerton.

A——— monile. Crockerton. Interior occupied by chalcedony; the thin coating which remains in the place of the shell itself is opake, white, effervescent, and has the pearly lustre.

A——— planus. Crockerton: shell iridescent.

A——— Rhotomagensis. Ridge.

A——— Selliguinus? Ridge.

A——— tuberculatus. Ridge.

A——— varicosus. Ridge.

Astacus. The abdomen, and portions of a claw. Ridge.

Auricula inflata. Pl. XI. f. 11. Ridge?

Belemnites attenuatus. Ridge?

Caryophyllæa. Ridge.

Cytherea parva? (*Venus*, Min. Con.) Ridge.

Dentalium decussatum. Ridge.

D——— ellipticum. Vale of Wardour.

Hamites attenuatus. Vale of Wardour.

Inoceramus concentricus. Vale of Wardour.

Inoceramus sulcatus. Vale of Wardour.

Natica. Two indistinct specimens, probably of different species. Vale of Wardour.

Nucula pectinata. Crockerton.

Pecten orbicularis. Crockerton.

Pectunculus umbonatus. Ridge. Crockerton: bottom of the clay.

Pentacrinus, joints of. Pl. XI. fig. 4. Vale of Wardour: same species as at Folkstone.

Plagiostoma elongatum. Ridge.

Rostellaria carinata. Pl. XI. fig. 19. Ridge.

Serpula. Crockerton: filled with phosphate of lime, in clay.

Solarium conoideum. Pl. XI. fig. 14. Vale of Wardour: preserves its iridescence.

S——— ornatum. Pl. XI. fig. 13. Vale of Wardour: probably from Ridge.

Terebratula ovata? Crockerton: in pyrites.

T———. Ridge: in a Septarium of phosphate of lime, with thin veins of calcareous spar.

Trigonia alæformis. Vale of Wardour: below Fovant? in clay, with numerous green particles.

Venericardia tenuicosta. Pl. XI. fig. 7*. Vale of Wardour: in Crockerton.

Venus parva? (See *Cytherea.*)

Fish. Teeth: Vale of Wardour. Vertebræ and rays: Ridge.

[*Purbeck Strata.*]

Cardium? Castleditches: Purbeck (or Portland?) stone.

Corbula? Between Dallard's Farm and Catherine Ford: with Cyclas.

Cyclas angulata. Pl. XXI. fig. 12. Between Dallard's Farm and Catherine Ford: with *Cypris granulosa*, Pl. XXI. fig. 4. in slaty Purbeck stone; with Corbula and Ostrea. Lane above Benston, near Chicksgrove: with Cypris and Modiola.

C—— elongata. Pl. XXI. fig. 9. Teffont: with *Cyclas membranacea.*

C—— *major?* Between Dallard's Farm and Catherine Ford. Purbeck;—or Hastings sand?

C—— *media.* Pl. XXI. fig. 10. Between Dallard's Farm and Catherine Ford: in slaty limestone; some specimens of which are almost composed of this shell. Dashlet, between Teffont and Penthurst, with Cypris. Ladydown Tile-pits, composing nearly the whole of the slaty stone. Between Ham-cross and Chicksgrove, with *Cypris Valdensis.* Fovant Wood. Teffont: in slaty limestone, apparently the top of the Purbeck, with *Cypris Valdensis.*

C—— *media*: A gibbose variety; as at Penhurst, near Battle in Sussex, (*supra*, p. 177.) Pl. XXI. fig. 11. Vale of Wardour, with *Cypris Valdensis.*

C—— *membranacea.* Teffont: with *Cyclas media* and Ostrea.

C—— *parva?*. Pl. XXI. fig. 7. Between Ham-cross and Chicksgrove: with Cypris and *Paludina elongata.* Dallard's Farm, where many of the Cyclas casts are full of the valves of Cypris.

Cypris granulosa. Pl. XXI. fig. 4. Between Dallard's Farm and Catherine Ford: with Cyclas, in slaty Purbeck stone; also with Cyclas and Modiola, in gray freshwater limestone. Dashlet, between Penthurst and Teffont.

C—— Valdensis. Pl. XXI. fig. 1. Vale of Wardour. Ladydown Tile-stone pits: with a variety of *Cyclas media*. Between Teffont and Penthurst. Between Ham-cross and Chicksgrove; Teffont; and stone pits south of Ridge; with *Cyclas media*.

Modiola. Dashlet; between Penthurst and Teffont: in decomposed slaty limestone. Between Dallard's Farm and Catherine Ford: with Cypris, in gray freshwater limestone.

Ostrea distorta. Pl. XXII. fig. 2. Quarry, below Fovant; in very compact stone, like mountain limestone. Between Dallard's Farm and Catherine Ford: with Cyclas. Teffont: with *Cyclas media*, and *C. membranacea*.

Paludina elongata. Between Ham-cross and Chicksgrove: with *Cyclas media* and *Cypris Valdensis*.

P—— a minute species; as at Combe-wood, Oxfordshire. Stone-pit south of Ridge.

Fish. Remains of the following species of Agassiz:—

Lepidotus minor. Ladydown Tile-stone pits: some very fine specimens, like those of the Isle of Purbeck.

Pholidophorus ornatus, *Ag*. Imperfect remains of a new species. Chicksgrove-mill Quarry: In white slaty limestone, full of fragments of shells.

[*Portland Stone.*]

Ammonites biplex. Tisbury: in chert; the shell chalcedony.

A—— *Brodiæi*. Fonthill Gifford.

A—— *giganteus*. Vale of Wardour: in chalcedony. Chicksgrove-mill Quarry: in gray limestone like chalk. Same place: in stone coated with rhomboidal carbonate of lime. Tisbury: in chert; the shell chalcedony.

Astrea Tisburiensis (*Madrepora Tisburiensis* of Miss Benett). In dark chalcedonic chert: a concretional bed subordinate to the Portland stone, near Tisbury.

Astarte cuneata. Chicksgrove-mill Quarry. Chilmark Quarry. Tisbury: with *Cerithium? excavatum*.

Buccinum naticoïde. Pl. XXIII. fig. 4. Vale of Wardour.

Cardium dissimile. Vale of Wardour. From the lane above Berston: with *Trigonia gibbosa*. Tisbury: in white uniform chalk-like stone.

Cerithium? excavatum (olim *Turritella*). Vale of Wardour. Tisbury: with *Astarte cuneata* and *Trigonia gibbosa*. Ladydown.

Cancer? or *Astacus?*. Claw, with *Trigonia gibbosa*. In slaty limestone. Lane above Benston.

Cytherea? rugosa. Pl. XXII. fig. 13. Chicksgrove-mill Quarry.

Echinus. Tisbury.

Exogyra (new). Vale of Wardour. Portland-stone?

Lucina Portlandica. Pl. XXII. fig. 12. Lawn Quarry: in sandy Portland stone.

Modiola. Vale of Wardour: in compact sandy Portland stone, Bevis's Quarry near Tisbury; with Ostrea, Serpula, and palate bones of fish.

Mytilus. Ashley Wood, near Fonthill Gifford: in compact Portland rock.

Natica elegans. Pl. XXIII. fig. 3. Miss Bennett's collection. Vale of Wardour.

Nerita sinuosa. Chilmark Quarry and Tisbury.

Ostrea expansa. Vale of Wardour; Chicksgrove-mill Quarry; in white chalk-like stone.

O—— falcata. Pl. XXIII. fig. 1. Chicksgrove-mill Quarry:—Top of the Portland.

O—— *undulata.* Vale of Wardour: in white chalk-like stone.

Pecten lamellosus. Vale of Wardour. Chicksgrove-mill Quarry. Shaver's Bridge, Tisbury Parish: with Ostrea, very young. Fonthill. Lawn Quarry; with *Lucina Portlandica*, in sandy Portland stone.

Serpula. Bevis's Quarry, near Tisbury: with Modiola, and palate-bones of fish; in compact sandy Portland stone.

Terebra Portlandica. Pl. XXIII. fig. 6. Tisbury: casts of interior, not effervescent.

Trigonia gibbosa. Vale of Wardour: Castleditches; with a minute Turbo. A lane above Benston, near Chicksgrove; with *Cardium dissimile*, crab's claws, and an Ostrea, in white chalk-like limestone. Chicksgrove-mill Quarry. Teffont. Tisbury. Fonthill Gifford: in chalcedony.

T—— *incurva.* (Miss Benett.) Vale of Wardour.

Turbo (minute.) Castleditches: with *Trigonia gibbosa.*

Turritella excavata. (See *Cerithium.*)

Fish, part of a palate. Tisbury.

[*Portland Sand* (*or Kimmeridge Clay*?).]

Ammonites biplex. Chicksgrove Mill: in sandy clay at the bottom of the quarry.

A—— Cast. Brickyard near Shaftesbury.

Panopæa depressa. (*Mya*, Min. Con.). Pl. XXIII. fig. 9. Near Shaftesbury: in clay. Some specimens very large.

North Wiltshire.

(139.) *Devizes, Calne.*—My knowledge of the country from the Vale of Wardour to the vicinity of Calne is due to my friend Mr. Lonsdale, with whom I had the pleasure of going over a part of it, in the year 1827. Mr. Lonsdale himself has since published a very important paper on the oolitic district of Bath, which is accompanied by sections, three of which include the strata under consideration in this paper*; and he has been so kind

* Geol. Trans., 2nd Series, vol. iii. p. 243, Plate XXXII. The course of these sections is expressed in the Map, Plate IX., by the dotted lines adjacent to No. 15. and 16.

as to furnish me with two additional sections, Nos. 15. and 16. (Plate X. a.) which may be considered as supplementary to those above mentioned; the first, No. 15., running east and west, from Etchilhampton Hill south-east of Devizes, to the Kimmeridge clay beneath the green-sand which caps the heights of Poulshot Green: the second, No. 16., from the lower chalk at Beacon Down, through Sandridge Hill, which is capped with the Lower green-sand over Kimmeridge clay and Oxford oolite, to the Oxford clay around Melksham, where the canal is about 154 feet above the sea*. The sections themselves sufficiently explain the general relations of the strata; and for an account of their composition I refer to Mr. Lonsdale's paper; regretting only that his colouring of the Ordnance Maps of that part of England still remains unpublished.

The town of Devizes stands upon a platform of the Upper green-sand, which is there about 430 feet† above the sea, and is overlooked by the chalk of Etchilhampton Hill and the adjacent heights. And here, as throughout the tract from hence to Swindon, the contrast between the upper and lower chalk is very remarkable, both in external features and agricultural character.

The ground near Westbury rises with such rapidity, that the distance between the outcrop of the upper chalk and of the Upper green-sand is less than a mile; and on the north-east of that town the slope is still more rapid. But, thence towards the north and east, a great superficial extent of the lower beds is exposed in the Vale of Pewsey, which consists of the Upper green-sand surmounted by detached portions of the chalk-marl and lower chalk, the latter, in some cases, rising into summits of considerable elevation.

The outcrop of the Upper green-sand and Gault has, in general, though irregularly, a northern direction, from about Great Cheverell, through Pottern,—to Heddington, about three miles north of Devizes. On the south of the Vale of Pewsey, the Lower chalk is disclosed by denudation, on a line almost due east from Easton Hill,—through St. Ann's Hill, Milk Hill, Golden Ball, Hewish, Martensell, and Terrace Hills; and thence westward through Easton, Milson, Pewsey field, Upavon, Cleeve Hill, and the slope thence towards Urchfont, and southward to the upper part of West Lavington. The outcrop of the Upper chalk, after forming a bold escarpment, between Westbury and Cheverell Hill, is thrown back towards the east, forming the heights, along which the *Ridgeway* is conducted, between Gincross by Bushton Down to Wivelsford. The Ridgeway, which runs on the verge of the ridge bounding the wide tract of Blackheath, is first directed

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* This and some other heights mentioned hereafter, are derived from Bradshaw's map of the canals of England, and are counted from low-water mark at Liverpool. (See Appendix C.)

† 429 feet 6 inches above low-water at Liverpool. At this level the Kennet and Avon canal is continued in a direction nearly parallel to the heights of chalk, as far east as the vicinity of Wooton Rivers, where it rises to 462 feet 6 inches (the summit level) to surmount a narrow neck of elevated ground on the north of Burbage:—and thereabouts the streams divide; one group running west, throug Pewsey, to join the Avon near Upavon; the other north-eastward, along a valley descending rapidly from north to south, through Great and Little Bedwin; and thence through Salisbury to the sea at Christchurch.

to the east of north, between Gore Cross and Bushton Down, but turns suddenly eastward immediately on the south of Urchfont. On the east of the Avon, the range of the upper chalk is less distinct; but it is directed towards the parting of the streams on the south of Burbage.

The difference between the upper and the lower chalk is very well expressed in the Ordnance Maps, especially in the more recent sheets, which are engraved with more lightness and delicacy of expression than some of their precursors. The great natural district of Salisbury Plain, more than twenty-five miles in extent from west to east, and twelve miles from north to south, though diversified by numerous irregularities, is almost wholly destitute of streamlets; and would be without running water, but for the presence of the more considerable rivers, which, in many cases, do no more traverse the surface of this region, the greater part of their supplies being derived from a different soil, and remote situation. This point of structure is known to be so characteristic of the Upper chalk, both in England and France, that good maps alone,—such as that of the Ordnance, or even of Cassini's map of France, would be sufficient to indicate the space occupied by this stratum. In the tracts, on the contrary, occupied by the Lower chalk—and still more decisively in the Chalk marl, few, even of the smaller valleys, are without streams; and hence, as well as from the difference in soil, the vegetation also is different, and the fertility of the lower regions forcibly contrasted with the naked and barren aspect of the higher downs. Were it not that the colour is so nearly alike, these two groups would no doubt have been distinguished in geological maps by different hues; and they ought to be so, wherever the scale is sufficient to express the distinctive features above mentioned.

(140.) *Vale of Pewsey.*—The general structure of this tract is fully described in the excellent paper of Dr. Buckland to which I have already referred. It is, in fact, a valley of elevation: its eastern and narrower portion being a continuation of the anticlinal ridge, which Dr. Buckland has described as extending from the south-east of Inkpen in Berkshire to the west of Shalbourne and Ham; where the Upper green-sand has been brought to the surface by subterraneous force, but is separated by a sort of bridge of the Lower chalk, about Burbage, from the portion of the former stratum which has been elevated in the same manner within the Vale of Pewsey itself. At the opening of the Vale, however, between Great Cheverell, Urchfont, and Devizes, no derangement is apparent, though it is very probable that the surface is disjointed by less perceptible fissures;—the Lower green-sand, continuously, occupying the whole of the entrance of the vale; as is expressed on the map, and more distinctly shown in fig. 4. of Mr. Lonsdale's sections. It will be observed that the beds immediately below the chalk are here more fully developed than in the Vale of Wardour, the Lower green-sand being perfectly distinguishable; as might have been expected, from the proximity of this place to the great expanse of that stratum in Surrey and Hampshire: and these subdivisions continue to be distinct through the northern counties as far as the coast of Norfolk. The small number of fossils which I could obtain, in addition to those enumerated in Mr. Lonsdale's paper*, are men-

* Geol. Trans., 2nd Series, vol. iii. p. 266, &c.

tioned in the list subjoined. One of the most remarkable is the *Diceras Lonsdalii*, Pl. XIII. fig. 4, for some very fine casts of which I am indebted to Mr. Goodhall.

No trace of any member of the Wealden group, nor of the Portland series, has yet been observed in this quarter; and it will be seen from the Section, No. 16., that the Kimmeridge clay and Oxford oolite thin out rapidly in rising towards the west at Sandridge Hill.

(141.) *Swindon.*—I am indebted also to Mr. Lonsdale for my first information as to the existence of the Portland stone and sand at this place,—and the occurrence there of large nodular masses of stone identical with those of Shotover in Oxfordshire, and of the French coast near Boulogne. The Section, Pl. X.a., No. 17., explains the succession and general relations of these strata. It will be remarked, that the Lower green-sand is distinguished from the Upper by the interposition of the Gault*: but though the Portland stone forms one of the most prominent features of this Section, no trace either of the Weald-clay or the Hastings-sands has yet been observed above it, and the indications of the Purbeck strata are inconsiderable.

Chalk.—The remarks above stated on the contrast between the spaces occupied by the Upper and the Lower chalk, apply with even greater force to the tract between Calne and Swindon,—or more properly between Cherhill and Liddington,—than to Salisbury Plain. The heights from Hackpen to Barbury Hill, that of Liddington Castle, and the high range thence to Polton Down, forming prominences above the lower chalk on the west and north-west, and bounding an extensive district, distinguished by the absence of streamlets and other characters from the more fertile regions of the lower chalk and chalk marl.

Between Barbury and Liddington Castle, the Upper chalk retires to the south and east towards Ogbourn St. George, so as to form a sort of amphitheatre. The outline of the higher summits when seen from sufficient distance, is in many cases almost rectilinear and horizontal; of which the ridge between Ogbourn St. George and Ogbourn St. Andrew affords a good example.

The Lower chalk forms a lower and uniform escarpment from Compton Basset on the east of Calne to the village of Liddington, and thence northward nearly to Little Hinton and Bishopstone. From the lower beds at Liddington a copious spring breaks out, in a position analogous to that of Lydden-spout on the coast near Folkstone (8.), and of the range of springs which everywhere appears at the foot of the chalk downs (70.)

Enormous masses of siliceous grit (Grey wethers), like those which occur in profusion near Marlborough, and in several places over the great chalk district on the south of that place, are sometimes found here beyond the chalk escarpment. One of these, about 12 feet by 8 in its diameters, was about a mile from the chalk-hill at Burdrop Wood; and with these, in some instances, are masses of siliceous conglomerate,—the Hertfordshire pudding-stone.

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* In the first edition of Mr. Greenough's map, the spaces assigned to the Chalk and Greensands here, are erroneous: the boundary of the latter on the north-west being really that of the lower chalk; and that of the Chalk, as expressed in the map, being truly the limit of the upper chalk only.

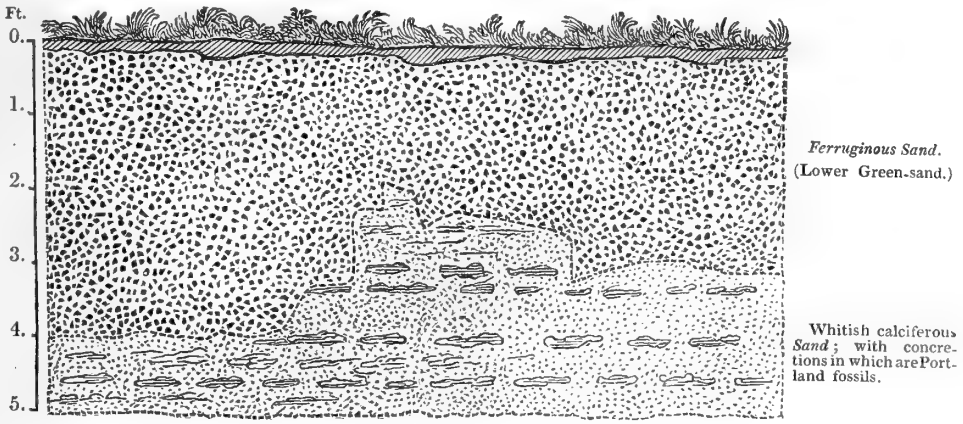
The *Upper green-sand,* from Wroughton to Warborough, includes dark-coloured siliciferous stone, containing mica and green particles. The formation occupies a slightly prominent step beneath the sloping escarpment of the lowest chalk. Its thickness is probably between 30 and 50 feet (see the Section, Pl. X. a., No. 17.); and it may be traced throughout a space of very irregular outline from the road at Burdrop Wood to Liddington.

Gault.—Bluish clay, of a smooth plastic texture, with numerous specks of mica, succeeds the last formation, and occurs at considerable heights in the sloping face of the escarpments. It can be recognised in the lower ground, on the roadsides, from Swindon to Burdrop Park, and to Liddington; but does not here form so distinct a valley or depression, as in Kent and Sussex.

Lower green-sand.—This, though perfectly distinct, can scarcely be said to form a ridge, as in the south-eastern counties, after rising from beneath the gault. It does, however, occupy a slight wave or inequality of the surface, about midway between Liddington and Coate (see the Section, Pl. X. a. No. 17.); and then suddenly thinning off, caps the heights at the latter place and at Swindon. The sand at the upper part is very tough, either from the presence of clay, or a great abundance of oxide of iron. In some other places it is loose and white; and among the substances found within its range is Fuller's-earth.

This ferruginous sand, as it approaches Swindon, rests, in several places immediately upon another sand of a very different character, at the top of the Portland series, and the junction is deserving of notice, the surface of the latter sand being very irregular, as if from erosion by water, and the inequalities or prominences often of such tenuity, as to indicate a very tranquil condition of the fluid beneath which they were formed, as well as of that which deposited the ferruginous mass by which they are at present enveloped:—which is the more remarkable, when it is considered that the interval between the deposition of these two sands must have been, in point of time, sufficient for the accumulation of the whole of the Wealden group.

In one of the quarries, near the top of Swindon Hill, the Section was thus. The boundary



between the two kinds of sand being perfectly distinct and sharp; and the contrast was the more striking, from the lower being composed, in a great measure, of minute fragments of shells, which are wholly wanting in the incumbent matter*.

* In Mr. William Smith's Geological County Maps of Kent, Sussex, Wilts, Oxfordshire, Bucks, Berkshire, and Bedfordshire, the stratum now known as the Lower green-sand is described as "Sand, in the lower part of which the Portland stone is found." To understand the source of this error, it must be recollected that at the period of those publications, the existence

Purbeck strata.—The only indication of this member of the Wealden which I found at Swindon, were detached masses of botryoidal limestone, like the middle of the "Cap", in Portland (p. 222.), and fragments of dark brownish silicified wood,—fallen, I have no doubt, from the top of the quarries, though supposed by the workmen to occur amidst the stone itself. In the looser matter also, near the top of the quarries and above beds of the Portland stone, are masses including very numerous casts of marine shells (apparently Lucina and Cytherea), in which the cementing substance has the aspect of freshwater limestone, and is scarcely to be distinguished from a stone of the same yellowish hue, within the Purbeck series near Ridge in the Vale of Wardour;—but in the latter the casts are those of *freshwater* species, especially Cyclades. In the subjoined sectional list, it will be found that clay occurs in detached portions above the Portland stone, in the great quarry at Swindon; but I was not enabled to determine the formation to which it ought to be referred.

Portland stone.—The upper part of this formation at Dayhouse farm, east of the Reservoir, and at Broom farm on the west of that place (Section No. 17.), abounds in the characteristic fossils, and is immediately subjacent to ferruginous sand. In many of the quarries here, especially in the east of the town, even the uppermost beds contain a large proportion of sand; presenting, in this respect, a striking contrast with the top of the series on the south-east coast, but much resembling that of the Lower Boulonnois, especially of the quarries at Mont Lambert. The stone is generally dispersed throughout this sand, in rugged and irregular concretional masses, which, as well as the sand, contain numerous obscure remains of shells, frequently in the state of a calcareous powder.

The following is a sectional list of the strata in the great quarry on the south-west of Swindon, which occupies a space of no less than fourteen acres; the beds rising from a point a little east of south, at an angle between 1° and 5°*.

Section of the Great Quarry at Swindon.

	Ft.	In.
1. *Soil*	0	6
2. In some places, immediately below the surface is *clay*, occasionally $2\frac{1}{2}$ feet thick, with a slight covering of ferruginous (Lower green) sand. But in several places the thickness of this sand was as much as 4 feet		
3. Loose rubbly stone	3	0
4. A group, as follows:		
a. Limestone full of petrifactions. *Cardium dissimile; Cytherea? rugosa*, Pl. XXII. fig. 13.; *Gastrochæna?; Lucina Portlandica*, Pl. XXII. fig. 12.; *Perna quadrata; Pleurotomaria; Terebra Portlandica*, Pl. XXIII. fig. 6.; *Trigonia gibbosa; T. incurva;* Long bones of Saurians	5	0
b. Bluish grey limestone		
c. Clay		
d. Soft limestone, abounding in casts of shells		

of the Wealden group was unknown; and that in point of fact, the Portland stone *is* found in many parts of the counties above mentioned, *at the bottom of the Lower green-sand*, and in a group which is itself in part composed of sand:—so that where the latter sand is not well distinguished, as in the section represented in the woodcut on the last page, the whole might easily be mistaken for one continuous stratum. What is stated above, explains, I believe, the true relations of these sands, to each other and to the Portland stone.

* A mill on the north of the hill was deprived of water in consequence of the springs which appear at the junction of the Portland sand with the clay, having been opened on the south-west side of it,—so as to tap, as it were, the summit, and draw off the whole of the water; the retentive surface of the clay being inclined towards the south. This fact proves also the continuity of the beds which form the top of the hill, and the absence of fissures—of such depth, at least, as to penetrate the clay.

	Ft.	In.
5. Alternate ranges of sand and stone.		
a. Sand, in many places cream-coloured, abounding in fragments of shells, which decompose into a white powder. This includes *b.*		
b. Stone, resembling that of the Portland formation in the Isle of Purbeck, evidently nothing more than sand consolidated by calcareous matter. The masses, when discrete, are of very irregular figure. The stone becomes more abundant in descending; and near the bottom contains very large Ammonites, *A. biplex*, *A. giganteus*	20	0
Total .....about	30	0

A depth of about six feet below the bottom of this quarry is said to consist of similar sand and stone.

Portland Sand.—The lower part of this formation is well displayed in an old quarry on the northern brow of Swindon Hill, near the letter *B* of the word *Bowling-green* in the Ordnance Map. The rock consists of rough sandy stone, of a dull bluish grey colour, like that of the upper part of this formation in the Isle of Purbeck, in which are included traces of several fossils converted into carbonate of lime;—*Ammonites biplex*, *Perna quadrata*, *Trigonia gibbosa*, *Trigonia clavellata*; with numerous dark particles of silicate of iron, and worn fragments of black chert or flint, many of them evidently the remains of casts of bivalves (some having the outline of a Venus or Lucina?), and of Ammonites.

Another form which the Portland-sand assumes here, is that of great nodules of hard greenish and grey calciferous grit, precisely resembling those of Shotover Hill, and of the French coast, especially near Cape Grisnez,—and, as at those places, imbedded in grey sand: above which, is another bed of sand without nodules, containing green particles and numerous fragments of black chert. Mr. Lonsdale had long since mentioned to me these great masses, several of which were then visible on the east of the road from Oxford, close to the town; but when I visited the place, the greater part of them had been broken up and removed. Immediately below the nodules were about four feet of grey sand.

The Portland-sand extends westward from the town of Swindon, and occupies a part of the descent of the hill at Okus and Westleaze, where the high ground overlooks the canal. In the farm-yard at Okus were several large nodules, like those above mentioned*.

Kimmeridge clay.—At the Bowling-green the sand with concretions appears on the surface as the hill descends, and is succeeded abruptly by dark clay, in which I found fragments of oyster-shells; and this is the case also beneath the great nodules near the road from Swindon to Oxford. I have no evidence of the identity of this clay with that of Kimmeridge, but the facts here stated.

(142.) *List of Fossils from the Strata below the Chalk, in part of North Wiltshire.*

[*Upper Green-sand.*]

Ammonites dentatus. Rowde Hill, near Devizes.
A———— varians. Near Swindon; (in the *Chalk marl*).
Mya mandibula. Devizes Canal.
Panopæa plicata? Rowde Hill.

* Toothill, a small eminence, which is conspicuous from this place, consists of clay, as also the hill at Elcomb-house. That of Chaddington, still further west, is said to be capped with sand.

Terebratula nuciformis. Rowde Hill.
Vermetus umbonatus. Rowde Hill.

[*Lower Green-sand.*]

Arca? Lockswell Heath, near Bowood: in ferruginous coarse sand-rock.
Corbula? Lockswell Heath: in ferruginous sand-rock.
Cardium striatulum? Lockswell Heath.
Cucullæa. Lockswell Heath: in ferruginous sand-rock.
Diceras Lonsdalii. Pl. XIII. fig. 4. *a.—d.* Near Calne. Mr. Goodhall.
Modiola. Lockswell Heath.
Mytilus. Lockswell Heath.
Pecten obliquus. Lockswell Heath: in ferruginous sand-rock.
P—— quinquecostatus. Lockswell Heath.
Plagiostoma rigidum. Lockswell Heath.
Terebratula latissima. Lockswell Heath: in ferruginous sand-rock.
T——— nuciformis. Lockswell Heath: in ferruginous sand-rock.
T——— oblonga. Lockswell Heath.
Thetis minor. Lockswell Heath: in ferruginous sand-rock.
Trigonia gibbosa? Lockswell Heath.
Turbo moniliformis. Lockswell Heath: in ferruginous sand-rock.
Venus? Lockswell Heath.

[*Portland Oolite.*]

Ammonites biplex. Swindon.
A——— giganteus. Swindon.
Buccinum angulatum. Swindon. Pl. XXIII. f. 5.
B—— naticoïde. Swindon. Pl. XXIII. fig. 4.
Cardium dissimile. Swindon.
Cytherea rugosa. Pl. XXII. f. 13. Swindon. The predominant shell in the upper bed of the great quarry.
Gastrochæna. Swindon.
Lucina Portlandica. Pl. XXII. f. 12. Swindon: in stone very like freshwater limestone; full of moulds and casts of this shell.
Nerita angulata. Pl. XXIII. f. 2. Swindon.
Ostrea falcata. Pl. XXIII. fig. 1. Swindon.
Pecten. Swindon: in stone, very like the Forest Marble.
Perna quadrata. Swindon.
Terebra Portlandica. Pl. XXIII. f. 6. Swindon. In great profusion, in the stone of the great quarry. Some specimens stained with oxide of iron; with Lucina. The impressions of the interior sometimes beautifully preserved.
Trigonia incurva. (Miss Benett.) Pl. XXII. f. 14. Swindon. Tuberculated ridges.
T—— gibbosa. Swindon.
Trochus? Swindon.

Wood. Silicified specimens of coniferous wood, in fragments, the cavities of which are lined with minute crystals of quartz, are found in the debris of the great quarry at Swindon: they are supposed by the quarrymen to have been found within the solid stone; but there can be scarcely a doubt that they have fallen from the beds above, the place of which corresponds to that of the group which affords the silicified trunks in Portland.

[*Portland Sand.*]

Ammonites biplex. Swindon.
Ostrea (deeply concave). Swindon.
Pecten. Swindon.
Perna quadrata. Swindon: with Mya?
Pullastra. Swindon.
Trigonia clavellata. Swindon: in bluish sandy clay; with pebbles of black flint or Lydian stone.
T——— gibbosa. Casts in dark flint, with Pecten or Lucina?

Bone. Portions of a long bone of a Saurian.

[*Kimmeridge Clay.*]

Ammonites. Near Steeple Ashton: in slaty lignite, like the Kimmeridge "Coal".

Berkshire, Oxfordshire, Buckinghamshire, Bedfordshire.

(143.) The tract between Calne and Bedfordshire derives its exterior character in a great measure from the very slight inclination of the strata, which in their progress towards the north-west from the anticlinal line of the Vale of Wardour, are comparatively undisturbed: no conspicuous faults, at least, have hitherto been detected between South Wiltshire and the northern coast of Norfolk, though it is probable that this region is not more exempt from slight disturbances, than the greater part even of the more uniform tracts in England is found to be, when examined with sufficient attention. One effect of this very gradual rise of the strata is, that some of the beds, shooting out successively to great distances, have been the subject of extensive denudation; so that outliers occur in several places at the distance of some miles from the general line of the escarpments: and on the confines of Berks and Oxfordshire a large tract, entirely denuded of chalk, appears, along the course of the Thames between Abingdon and Reading, breaking in upon the almost uniform and linear course which the outcrop of that formation would otherwise have followed from Calne to the fens of Cambridgeshire. It is not improbable that this wide denudation, and the course of the Thames

itself, may have originated in a preexisting fissure, by which the direction of the principal stream may have been determined, and the effect of the denuding waters subsequently modified.

My observations were resumed, on the north of Swindon, in the tract around Hazeley and Garsington; and the country thence through the contiguous counties of Oxfordshire, Bucks, and Bedfordshire, as far as Woburn, is so much alike in geological structure and composition, that the whole may with advantage be considered together. I shall therefore first state generally the order and composition of the strata, and then illustrate the sections Pl. X. a., Nos. 18, 19, 20, and 21, with some details derived from points where the beds are best exhibited. The recent sheets of the Ordnance survey, Nos. 13, 45, and 46, are so well executed as to furnish all the assistance that can be desired in the examination of this part of England: and their aid will be almost necessary in perusing these remarks *.

Chalk.—The most striking feature in the outline of the chalk, north-east of Swindon, is the sudden retreat of the Downs above referred to; by which the escarpment is thrown back towards the south between Woolstone, on the west of Wantage, and Watlington, not less than eight miles. The subsequent direction of the outcrop is nearly parallel to that of Marlborough Downs, and through its whole course thence into Norfolk, the lower chalk and chalk-marl run out far beyond the escarpment of the upper strata, which, near Nuffield, on the main road from London to Oxford, through Nettlebed and Abington, is more than two miles from that of the chalk-marl at Gould's Heath. On the lines through Stoke Talmage and Tetsworth, the distance is nearly four miles; and the space varies between one and four miles all along the range, thence to the north-east of Dunstable, becoming still more considerable in the lower tracts of the east of Bedfordshire and Cambridgeshire, where the beds are less inclined.

The angle at which the strata in this part of England rise, in general towards the west of north, in many cases does not exceed 1° or 2°; and the contiguous beds are frequently so mixed at their junction, as to render it very difficult to define them. An additional source of obscurity occurs between Aylesbury and the road from Dunstable into Bedfordshire; where large accumulations of superficial gravel (comparatively recent, since it includes fragments of chalk,) mask the substrata, or totally conceal them. A remarkable deposit of the same kind in the south and south-west of Oxford, is mentioned by Mr. Conybeare†; and Dr. Buckland has made the transported matter of the Valley of the Thames, the subject of a paper in these Transactions, in which his views of the Theory of its production are fully explained‡.

Upper green-sand.—This formation is not generally so prominent in this tract, as in the counties near the coast; but its representative is found along the base of the chalk marl in all the places which I myself examined. Thus, on the line of the Abington road to Oxford, it appears on the descent from Gould's Heath towards Bensington; and firestone, I was informed, is obtained

* The authorities connected with this tract are, the general maps of Mr. Smith and Mr. Greenough, and the Sections and County Maps of the former. The only published description of the strata is that of Mr. Conybeare in the "Outlines of England and Wales", p. 170.—183, from which I have throughout derived most valuable assistance.

† Outlines, &c. p. 190.

‡ Geol. Trans., 1st Series, vol. v. p. 516—544.

by mining in the lower ground on the north-east of that place, between Rumbold Copse and Whitehouse Farm. The formation is much less distinct at Tetsworth, but is obvious on the south of that village; in the descent of the hill from Chinnor towards Emington; and beneath the lower Icknield-way, at Chadwell Hill on the north-west of Risborough; at North Lee, between Turwick and Bishopstone; and probably in the vicinity of Aston-Clinton. On the north of Totternhoe, great quantities of a soft variety of firestone were formerly obtained from mines of ancient date deeply seated at the foot of the lower-chalk escarpment, between the village and the hill on which is the mound of ancient encampment, called Maiden's Bower. In this latter direction, also, an outlying portion of the Upper green-sand is visible, on the road between Kate's Hill and the Turnpike near the beginning of Hockliffe, forming the base of an outlier, or peninsular portion of chalk, which shoots off from the main body about Chalton, and bears upon it the village of Wingfield;—not improbably crossing the road and forming part of a flat-topped range of heights, which extends westward on the north of Tilsworth and Stanbridge.

Gault.—The gault in this part of the country is very irregularly diffused, in many places forming a distinct valley or depression beneath the Upper green-sand, in others spreading itself towards the west, and thinning off gradually over the top of the Lower green-sand.

Lower green-sand.—This formation, which is indistinctly seen in the lower ground, is best observable near the summit of the heights between Garsington and Shotover on the south-west of Oxford (No. 18.),—and of the corresponding ranges, from Long Crendon to Brill (No. 19.), and from Quainton to Whitchurch, on the north-west of Aylesbury (No. 20. & X. b. fig. 11.) Thence towards Leighton Buzzard, the Lower green-sand is more obscurely seen: but it becomes conspicuous in approaching Woburn, and is found in immediate apposition with the Kimmeridge clay, at Little Brick Hill (No. 21′.), where the whole of the intermediate strata, from the Wealden to the Portland sand, are wanting,—having been either originally deficient, or partially carried away before the deposition of the sand.

The greatest extent of continuous surface which this formation occupies here, is between Leighton* and the west of Woburn. But there can be little doubt that it once extended continuously from its rise beneath the gault to its final outcrop in the heights above mentioned; the greater part having been subsequently removed by denudation.

On the main road from Tetsworth to Wheatley, Section No. 18′., a portion of the gault and of this sand still remains between the 44th and 47th milestones; while on the south-west of the road, a great part of these strata having been removed, the surface is so much lowered as to disclose the subjacent Portland stone, throughout a space which includes the villages of Great and Little Milton and Great Hazeley.

Several outliers of the Lower green-sand in this part of England still remain to be examined; among which the heights near Faringdon seem to be especially deserving of notice. Another detached portion (which, if the chalk range had been unbroken by the chasm of the Thames, would have been nearly at the same distance from the escarpment as that of Faringdon), caps the hills at Bagley Wood and Cumnor, on the south and south-west of Oxford. These have been generally described by Mr. Conybeare (Outlines, p. 190.), who states that the Portland beds do not extend so far: but as the relations of the Wealden group were unknown at the time of his

* A large tract around Leighton, including Wing, Cublington, Aston Abbots, Mentmore, &c., has not yet been described geologically. The late Mr. Bevan of Leighton was thoroughly acquainted with it; and I am not without hope that some of his observations may be published by his son.

publication, it may perhaps deserve inquiry, whether some portions of it may not exist beneath the sands in that quarter.

Wealden.—The traces of the upper members of the Wealden, are here so rare and indistinct, that nothing has yet come within my knowledge which can be referred to them, except on the summit of Shotover Hill, where shells, supposed to be of freshwater species, are found above the Portland strata, in a ferruginous sand or clay; and at Quainton and some other places in Buckinghamshire, where grit like that of Hastings, contains Paludinæ.

The lowest of the Purbeck strata are here fully characterized by their fossils, and precisely resemble the lower beds of this formation in the Vale of Wardour and on the Dorsetshire coast. They consist of slaty limestone, like the "tilestone" of Ladydown in the Vale of Wardour, and the "Slate" of the Sections in the Isles of Portland and Purbeck. With this stone, beds of clay alternate, which become more frequent in approaching the Portland strata, and clearly represent the "Dirt-beds" of that island and the adjacent coast. One of the lowest of these clays, contains thin layers of a species of Mytilus (*M. Lyellii*?) which is found in several detached points of the tract now under consideration. I did not, however, find in any of these beds either silicified trunks of trees, or of the remains of Cycadeæ; but in the corresponding place at Garsington in Oxfordshire, were detached fragments of silicified coniferous wood, like that of Portland. In several cases the more uniform freshwater limestone in this lower part of the Purbeck series is "Travertine"; and like the "Cap" of Portland it includes cavities incrusted with botryoidal carbonate of lime.

The fossils which this formation affords here, as in the Vale of Wardour, are Cypris and Cyclas in profusion, and of two or more species; Mytilus and Modiola; with, more rarely, Astarte and Paludina of two or three species, and some minute spiral univalves.

The *Portland strata* have been found in this part of England, throughout a tract between six and ten miles in extent from south-west to north-east, on the line of its rise from beneath the superior strata, (Pease Farm, near Great Hazeley, in Oxfordshire, to Bierton near Aylesbury, Bucks),—and about five-and-twenty miles, on the course of its outcrop, (from Garsington in Oxfordshire to near Stewkley, Bucks). They, no doubt, constituted at one time a continuous group, but having been cut through by irregular denudation, now exist principally in the upper part of the detached heights, which are separated by low ground excavated in the Kimmeridge clay.

The *Portland-stone* makes its first appearance north of Swindon, on a line directed from about south-east to north-west, through Easington, south of Little Milton and Garsington, towards Oxford. On the south of that line no stone is found; the villages of Chalgrove, Ascot, Stadhampton, and Chiselhampton being supplied with it from the Milton pits. Among the points where I have seen the Portland beds near their first rise from beneath the superior strata, are—a spot near the brook between Peg's Farm and Standhill, on the south-east of Great Hazeley (Section No. 18.); near Cotmore Walls, about a mile west of Thame (No. 19.); near the windmill at Towersey, Bucks; east of Kingsey; Haddenham Field, about half a mile west of the church; about midway between Ford and Moreton's Farm; near Bishopstone; Pistol Hill,—the vicinity of Walton, and of Broughton, near Aylesbury; and the summit of the heights at Bierton. Beyond this last-mentioned place, I could not learn that stone has yet been discovered; though, as it occurs at Church Farm on the road from Wing to Cublington, it may probably be found to rise between the chalk, at Ivinghoe and Totternhoe, and Wing. The Portland sand has been quarried between Tinkershole and Stewkley, and about a mile north of Dunton; and the out-

crop of the stone and sand, can be traced along a very irregular line, from the heights at Garsington and Shotover, by Brill and Muswell Hills, Ashendon, Waddesdon, Quainton, and Whitchurch, to the points last mentioned, near Stewkley, which seem to be their limit in this direction.

The *Portland-sand* goes out beyond the stone, on the north and north-west sides of the heights just mentioned. The sand is in some places loose, grey, and yellowish; but in general it abounds in green particles, and is often almost wholly composed of green matter: the bluish half-concreted mass, intermediate between stone and sandy clay, which is the predominating component of this stratum on the coast, being here of rare occurrence*. Near the bottom, the sand includes great nodular concretions of hard greenish grit, like those of Swindon, Shotover, and the Lower Boulonnois; and it contains sometimes worn, polished, fragments of very dark-coloured chert or flinty slate.

The Portland stone and sand are found between the principal ranges of Brill and Whitchurch, (Sections 19. and 20.), and nearly at the same level, in the heights of Ashendon, Lodge Hill, Chearsley, Over-Winchendon, Coney Hill, Cuddington, Dinton, Stone, and Hartwell. But on the north-east of the road from Aylesbury to Winslow they are rarely visible, being deeply seated, and concealed, especially in the vicinity of Leighton Buzzard, by large accumulations of gravel.

The intermediate and lower tracts between the lines of section and the heights above mentioned appear to be occupied by clay, and the whole district is in general undisturbed; no derangements at least, at all comparable to those of the Wealden tract, or of the Dorsetshire coast having yet been observed within it: but in many of the Portland quarries the beds of stone are traversed by fissures, produced by violence long antecedent to the present condition of the surface. An elevation comparatively inconsiderable, but analogous to that which has raised the anticlinal ridges of the south, occurs at Wheatley, between the range of Shotover and that of Brill,—both of which are capped by nearly conformable strata of Portland sand and stone, rising gradually to the north-west; while the beds of the Oxford oolite, which appear in the village of Wheatley, on the main road from London to Oxford, rise more rapidly northward, from beneath the stone and sands of Garsington and Combe Wood. (See and compare the Sections, Pl. X. a. No. 18. and 18′, and Pl. X. b. fig. 10.) A small portion, therefore, of the space between the heights of Shotover and of Brill may be occupied by an anticlinal ridge, or curve, of Oxford oolite.

Kimmeridge Clay.—This is found everywhere, in these sections, beneath the Portland sand; and is conformable to the superior strata. It is best seen on the west of Shotover Hill, where the series of the strata is complete; but near Leighton it seems to come nearer to the Lower greensand; and in the descent from the village of Little Brickhill, (Section No. 20.) it appears within a few feet of the sand, which forms the upper part of the hills there.

The whole of this stratum is disclosed, on the line of Section No. 18, at Headington; and its characters there are described by Mr. Conybeare†. It seems to increase in bulk in advancing northwards, but does not anywhere attain the thickness which it exhibits near Weymouth, in the Boulonnois, and near Scarborough. Its predominant fossil here is *Ostrea deltoidea*: near Aylesbury are found *Gryphæa virgula*, and Aptychus.

Professor Sedgwick has remarked that on the south-east coast near Weymouth, some of the same fossils pervade this clay, the mixed beds near Weymouth, and the oolite beneath them; and it

* Bluish stone, somewhat like that of the sands in Purbeck and Portland, is found near the top of this formation, at Hartwell near Aylesbury.

† Outlines, &c. p. 185.

graduates upwards also into the Portland sands. He supposes, therefore, that certain beds of the series are wanting between the freestone of the Headington quarries and the incumbent Kimmeridge clay; an inference confirmed by the condition of the surface of the freestone,—which Mr. Conybeare describes as exhibiting the appearance of having been marked by the action of water upon it, before the deposition of the clay; "presenting occasionally small cup-"shaped cavities, and perpendicular rents of various breadth, into which the clay had insinuated "itself*." It is not, however, improbable that some of the intermediate strata exist on the line of section from Garsington to Langcombe. See hereafter, p. 278.

Oxford Oolite (*Coral Rag* of Smith).—The characters of this group have been described by Mr. Conybeare. Its general course is nearly conformable to that of the upper strata, and is represented in Mr. Smith's and Mr. Greenough's maps. On the east of Islip a narrow interrupted ridge passes north-eastward, for about nine miles from Woodeaton, as far as Stanhill near Marsh Gibbon, and is separated from the escarpment of the Portland stone and sand at Muswell Hill (Section No. 19.), by a uniform flat, apparently occupied by clay. Blackthorn, a place upon the ridge, affords a bluish oolite, which Smith refers to the Coral Rag. This ridge appears to separate the Kimmeridge from the Oxford clay; but the continuity of the former so far westward from Muswell Hill, where it ascends considerably, implies a thickness much greater than that in the Headington quarries.

The regular course of the Oxford oolite is interrupted by the offset mentioned in the last page, which extends a little eastward of its general direction to Wheatley (see the Transverse Section, Pl. X. b. fig. 10.); the strata there rising towards the north, at an angle of about 9°. The previous dip about Garsington is much less; and that of the general range of this formation in Oxfordshire, according to Conybeare†, not more than 1°. This upheaving seems to be continued eastward for some miles, so as to bring up the Portland sands at a point much closer to the chalk near Thame, than on the north-east of that place.

(144.) *Section* Pl. X. a. No. 18,—*from the Chalk through Hazeley, Garsington, and Shotover, to Oxford;—and* No. 18′. *from Stokenchurch, through Tetsworth, to Wheatley.*—The upper strata between the Gault and the Portland stone on the line of Section 18, are best seen near the summit of the range from Combe Wood to Shotover Hill: and I am indebted to Mr. Hugh E. Strickland, for the following account of the ferruginous sand at that place, which I have not examined myself.

Shotover Hill:—[*Lower Green-sand, and Wealden.*]

"The bed which crowns the hill and rests on the supposed equivalent of the Portland stone, "consists of a series of sands, mostly ferruginous, but frequently assuming various shades of "yellow, white, grey, and even black, according to the proportion of oxide of iron which they "contain. The sand occasionally graduates into marl and clay; and seams of yellow ochre also "occur, which afford considerable supplies of that article. The stratification of the sands and "marls is often very tortuous and irregular, which seems rather to be owing to the circumstances "of their deposition, than to any subsequent action. In some cases the oxide of iron has been

* Outlines, &c., p. 189.

† Ibid., p. 192.

" so abundant as to concrete the sand into shapeless masses of great hardness, which occur in " local strata a few inches thick. Except in these masses of ironstone, no organic remains have " been noticed throughout the deposit. Taken as a whole, this formation bears a great resem- " blance to the Lower green-sand of Sussex; and the masses of ironstone are almost identical in " appearance with some which exist there: but the fossil shells lately found in it appear rather " to show that it forms a part of the Wealden group. These shells occur only in the nodular " masses of ironstone, which are scattered near the old sand-pits on the west end of the hill; and " were first noticed there by the Rev. H. Jolly of Bath."

[The shells here referred to by Mr. Strickland, appear to belong to five species: three of Paludina; a small bivalve, like a Cyclas; and a larger bivalve, like a Unio. But the specimens hitherto found are all too imperfect to admit of precise determination, and are none of them so unlike some of the species which occur in the Lower green-sand, as absolutely to exclude them from that formation.]

" A small pit had been sunk in quest of ochre at the side of the old London road, about 150 " yards to the east of the old quarry, where the large globular concretions of the Portland sand " occur. This spot may be about 50 feet above that quarry; and the pit presented the following " Section:—

	Ft.	In.
[*Wealden?*]		
" 1. Yellowish clay	4	8
" 2. Yellow ochre	0	4
" 3. Sand and rubbly marl	3	0
[*Portland.*]		
" 4. Very hard brown sandstone, with a few Trigoniæ, and a bone of a crocodile	1	0
" 5. Rubbly stone, with numerous casts of Trigonia, the shells having decayed into a " brown powder	1	0
" Total	10	0

" The first three beds exactly resemble the sandy strata which extend from this point to the top " of the hill, a height of about 50 feet, and which I am disposed to regard as belonging to the " Wealden group. The nodules of ironstone containing the supposed freshwater shells, occur at a " height of about 30 feet above No. 4."

Purbeck Strata.—What remains of the Purbeck strata in this part of the country is best seen in the pits in the southern part of the Shotover range, at Combe Wood and Garsington. The junction of the incumbent strata with the Portland beds, is first disclosed in the quarries at Great Hazeley.

The section at *Combe Wood* consists of,—

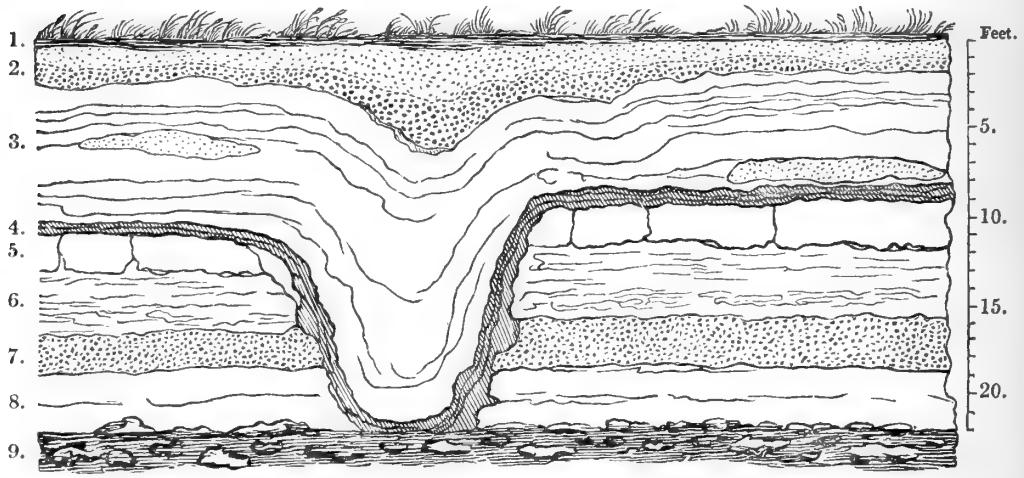
1. Reddish loamy soil, passing into 2.
2. Ferruginous sand (*Lower green*).
3. A thin bed of very tough clay (Fuller's earth?); which, with 2, enters into, and follows the deep erosions and irregularities at the top of 4.
4. *Purbeck.*—Stone, and soft rubbly matter;—(the "Malm" of the pits at Garsington); containing freshwater shells, like those of that place:—Cypris; Mytilus, two species; Modiola; *Paludina elongata*, and perhaps another species?; Planorbis?. Some portions of the stone are compact and uniform, with the usual characters of freshwater limestone; others, though containing the same fossils, are composed of grey and brownish, fine-grained, oolite, in which a very small

univalve—perhaps a Paludina—occurs in such numbers, as in some places to form nearly the whole mass.

5. *Portland stone*; with numerous Trigoniæ and Pernæ.

Great Hazeley.—In the principal quarry at this place the strata dip to about 20° east of south, at an angle of about 4°; and are traversed by joints nearly in the same direction. The order is as follows:

Stone-pit at GREAT HAZELEY.



	Ft.	In.
1. Soil, forming a level and uniform surface		
2. Loam, brown and red; containing fragments of ferruginous conglomerate, (carstone) and of a brown substance, like umber; passing below into ferruginous sand..3 ft. to	6	0
3. Thinly stratified firm clay or marl, of a light grey colour, approaching to stone, not effervescent, containing between the folia impressions of plants, and including portions of reddish sand, in horizontal masses of very unequal thickness. It breaks down rapidly in water, like Fuller's earth, and its place corresponds best (so far as my observations went) to that stratum?.....	6	6
4. Dark brown clay; like the Fuller's earth of Tilburstow (p. 139.), and of the pits near Aylesbury. Some of the masses into which it is easily divided, are polished, by sliding on each other under pressure. At the bottom ferruginous sand alternates with the clay ..... 1 ft. to	1	6

[All the preceding beds are much disturbed, and bent irregularly, so as to accommodate themselves to a chasm in the strata below,—here called a "Gull" (gulley?), and quite analogous to those in the Isle of Portland mentioned at p. 218. The manner in which these "gulls" are filled, proves that they must have been excavated before the deposition of the matter which now occupies them. But the surface of the ground above the opening shows no indication whatsoever of disturbance.]

The *Purbeck strata* seem to be wanting here?

[*Portland Stone.*]

5. Stone, called "Curl"; grey calcareous grit. Often blue, in the interior of the masses; containing thick oysters, and Pernæ .....about	2	0
6. Sand and clay, containing fragments of shells, and including at the bottom concretions of calciferous sandy stone, which abounds in petrifactions, especially *Perna quadrata*	4	0
7. Uniform whitish sand, and sandy stone, with *Perna quadrata*, and numerous Serpulæ.	2	6

[In another large quarry, 6. and 7. unite to form one bed about 7 feet thick.]

	Ft.	In.
8. "*Stone*", commonly in two beds; that for which the quarries are worked. It is like the Purbeck-Portland, and contains disseminated spots of pyrites. The under surface is often covered with petrifactions,—Perna, Trigonia, Venericardia, and Trochus. Bones have been found in it, and sometimes lignite	2	6
Bottom of the Quarry.		
9. Below is sand: precise depth and relations unknown .....about	12	0
Total about....	35	0

The principal stone-pits at Garsington, are in the western escarpment of the hill north of the village, overlooking the low ground about Langcomb and Cowley. One of the largest gave the following Section:—

Stone-pit at Garsington.—[*Lower green-sand, Purbeck, and Portland.*]

1. Loamy soil .....about	2	0
2. *a.* Ferruginous brown sand, including portions like umber, and irregular seams of clay, like that of the bed 3. at Great Hazeley, (Fuller's earth?). It contains also patches of greenish sand. *b.* A band of yellow ochre, about half an inch thick. *c.* A thin bed of uniform tough clay (Fuller's earth), in wax-like pieces, polished by motion under pressure	8	0
[These, like the upper beds at Great Hazeley and Combe Wood, follow all the irregularities of the mass below.]		
3. "*Malm*"; an agglomerate, composed of stone and softer marl-like matter, much decomposed. Among the components are,— *a.* Light greenish-grey marl, like some beds of the lowest chalk; containing at the upper part detached fragments of silicified coniferous wood, like that of Portland, and portions of bone. *b.* Firmer pieces of stone, with some oolitic particles, including small spiral univalves,—Paludina, perhaps of two species?; a Planorbis?; Mytilus; and Cypris..... *c.* At the lower part, the mass consists of larger pieces of uniform limestone, in some places like the "Pendle" of the pits at Whitchurch hereafter mentioned, and including small Paludinæ, with other small spiral univalves, Mytili and Cypris. Some of these pieces have the botryoidal structure of part of the Portland "cap" (Travertine); of which bed (or of the "Skull-cap") they seem for the greater part to be the representative: but others consist, as at Combe Wood, of fine-grained oolite, passing, however, into the compact stone, and containing the same fossils .....Total about	4	0
[The irregular cavities and waves at the top of this mass are very remarkable, resembling the erosions at the top of the chalk.]		
4. The *Portland stone* of these pits requires no particular description.		

The upper part of another pit, about half a mile east of that which furnished the preceding list, was nearly the same, but still more like that of Great Hazeley. A third pit close to it contained a "gull", as at p. 276.

The *Portland sand* is not visible in the descent from Garsington, but is very well seen in the escarpment of Shotover Hill; where the order, at the lowest part of the Portland series, is as follows:—

Escarpment, Shotover Hill.

Ochre; about 8 feet above the sand, 1.

1. Greenish-sand (*Portland*).
2. A bed of concretional masses of grit.
3. Greenish sand.
4. Beds of clay, about 3 feet thick.
5. Sand.
6. Great nodules of grit, with *Perna quadrata*, &c.
7. Greenish yellow sand.

Below is *Kimmeridge clay*.

(145.) The beds connecting the Portland strata with the subjacent Oxford oolite are exposed, in detached places, on the descent of the hill from Garsington to Langcombe and Gasson's Barn, where the following strata occur, beneath a considerable thickness of *whitish* sand, which, however, is probably a part of the Portland group.

Pits near Langcombe.

	Ft.	In.
1. Soil, including carstone.		
2. Rubbly stone (*Portland*).		
3. Yellowish sand, with petrifactions and calcareous matter interspersed	1	0
4. Sand, with Trigoniæ; concreted at the bottom		
5. Sand, including at the bottom 6..	1	0
6. Stone, in irregular concretions..	0	9
7. Sand; continuous (except where there is stone) with 5. and 9.	2	0
8. Concretional stone.... 6 feet to	8	0
9. Sand, as above.		
Total thickness .....15 to	20	0
[The preceding part of this section represents the Portland stone and sand of Mont Lambert in the Boulonnois.]		
10. Clay, (*Kimmeridge*) .....about	12	0
11. Blue grit in irregular concretions, with shells and stems of Siphonia?	3	6
12. Clay continuous with 10.; when dry, it is yellowish brown, approaching to ochre yellow .. about	40	0
This clay rises slowly towards the quarries at Langcombe, the distance of which from Garsington is about a mile.		

	Ft.	In.
After a thickness of between 40 and 50 feet of clay as above mentioned, there were, at *Gasson's Barn*, the following beds, abounding in Pectens and other smaller shells.		
1. Rubble full of broken shells	1	0
2. Rubble, somewhat slaty....about	10	0
3. Coarse yellowish sand, with whitish ranges, containing numerous fragments of shells	1	6
4. Stone in concretions		
5. Sand nearly as above, but finer, somewhat concretional	2	0
6. Stone; a congeries of shells, mixed with sand concreted by calcareous matter, and containing black flint pebbles, Pernæ, numerous small Gryphites and Pectens, and large flat bivalves.		
7. Sand connected with 5.	2	6
The lower part of this group seems to represent the Weymouth beds, or the upper part of the Coral rag.		

(146.) *Kimmeridge Clay.*—In one of the quarries at Headington, the clay over the Oxford oolite was thus:—

Clay-pits, Headington.

1. (Surface) "*Loam*"	5	6
2. "*Brick-clay*," with fragments of Oysters and Gryphites:—about 3 feet from bottom, full of small shells	6	6
3. "*Blue-stone*," in concretions, on an average about a foot in thickness.....	1	0

		Ft.	In.
4.	"Clay," dark muddy blue .....altogether about	11	0

At top containing Terebratulæ and Gryphites.
About 2 feet from top, a bed of *Ostrea deltoidea*.
At 4 feet from top, a second bed of the same.
About 7 feet, Ammonites and several small bivalves.
In some places Belemnites, at the lower part.

5 "*Rock*;" reddish yellow sandy limestone :—(*Oxford oolite*).

(147.) *Oxford Oolite.*—The section No. 18′ shows the manner in which this group comes in, after the gault and green-sand, on the great road from London; and the transverse section, Plate X b. fig 10., further explains its relation to the Portland stone and sands, which, in the eastern part of Section 18′ are either wanting, or concealed by a prolongation of the gault and green-sands. The Oxford oolite is seen, in the transverse section, to rise from beneath the heights, towards the west of north, at an angle of about 9°; and it is probable that all the strata here, from the Portland downward, decline more to the south than the chalk and the upper members of the series: they seem to form the southern slope of a curve or saddle, the opposite side of which would descend towards the north, somewhere between Wheatley and the Brill-hill range. The lower beds here are much harder than the rest; they consist of sparry limestone, including oolitic grains, and the masses are blue in the middle: I obtained from them an Ostrea; *Terebratula media*; *Melania Heddingtonensis*; and a Spongia.

(148.) *Section,* Pl. X. a. *No.* 19. *From the chalk, through Thame and Long Crendon, to Brill and Muswell Hill.*—The characteristic of the section on this line, is the distinctness with which the Portland sand is exhibited, almost throughout its course. The superior strata are best seen in the quarries around Brill, and at some points on the ridge between that place and Long Crendon.

The tract on the north and east of Chinnor, on the line thence to Thame, has very obviously been at one time the bottom of a sea or lake, over which the chalk impended as a lofty shore; and near which the tides or currents acted with such uniformity as to level down the ridge of the lower green-sand;—while on the west, the ranges of Brill, Quainton, Whitchurch, and other less prominent summits, stood out as banks or islands, at a short distance from the land. These relations are all very well seen from the ground about Barley Hill, on the north-east of Thame.

Gault.—At a point on or near the section, between Black Ditches Hill, Cotmore Walls, and Sydenham-hurst, a well had been sunk forty feet, and then bored to fifty more, entirely in tough dark blue clay, beneath which was sand rock.

Lower Green-sand.—In a great number of the quarries in this part of the country, the ferruginous sands at the upper part are separated from the rubbly stone beneath, by dark tough clay, 4 to 9 inches thick, which follows the irregularities of the mass below, and coats the bottom of cavities like the "Gulls" of Hazeley, (p. 276.). The stony matter seems to be either the "Malm" of Garsington and Combe Wood, or the representative of some other portion of the Purbeck series.

Sections at Brill.

A.—In a pit at this place, open in 1827, the following beds were visible above the Portland strata:—the whole (perhaps from subsidence) inclining towards the north-west.

	Ft.	In.
[*Lower Green-sand.*]		
1. Grey and yellow sand ..... about	6	0
2. Alternate layers of ferruginous sand, and of clay used for making tiles. Near the bottom the seams are oblique to the stratification	15	0
3. Black and grey, alternating with whitish and ferruginous, sand, and including flakes of yellow ochre	0	2
4. A thin course of clay (Fuller's earth), of various colours, green, wax-yellow, and reddish, with a subconchoidal fracture, and a wax-like, almost resinous lustre externally, like jasper. The polish of the pieces is evidently the result of movement under strong pressure.—See the description of a similar clay at Tilburstow in Surrey, *supra*, p. 139. ..... about	0	6
5. Sand, increasing in firmness as it goes down	4	0
[No indication here of the *Purbeck strata.*]		
6. *Portland stone*,—containing Trigoniæ and other characteristic fossils, among which *Pecten orbicularis* is one of the most abundant		

B.—At a clay pit about 20 feet below the road on the south-west of Brill, the beds, declining to the west and south, were thus:—

[*Lower Green-sand.*]		
1. Sand; white at top, yellow, and ferruginous below ..... 6 0 to	7	0
2. Gravel, with concretions of "Carstone"; coarse quartz sand, cemented by oxide of iron	1	6
3. Yellow ochre, of very good quality, much used in commerce ..... 1 8 to	1	10
4. Clay; containing thin bands of ochre, a quarter of an inch and less in thickness... about	1	0
5. Clay; light bluish grey, uniform: here visible to a depth of ..... about	5	0

No shells of any kind are known to occur in this bed; but about six feet down an entire tree was found, converted into lignite much mixed with pyrites. The trunk, about a foot in diameter, and full 40 feet long, lay almost horizontally, nearly east and west; and branches extended to about 10 feet beyond it on both sides, beginning about 25 feet from the extremity. It was preserved and shown in an adjoining house as an object of curiosity; and though in a state of ruin, when I saw it, from the decomposition of the pyrites, was one of the finest fossil specimens I had ever seen. Beneath the tree, it had been ascertained by boring, that clay, but of darker colour, extended to about 12 feet in depth.

C.—In another pit, on the outside of the inclosure where the tree was found, the strata were:—

Grey sand ..... about	5	0
(5.) Clay, said to be the same with (5.) of the list above; but darker and of more slaty structure. It is very like 4. of the List A. above, and breaks into pieces with polished surfaces: the lower part for about two feet alternates and is mixed with yellow ochre	4	6

The place of this clay in the series seems to correspond best to that of the Fuller's earth at the bottom of the Lower green-sand; and it falls to pieces slowly, in water, like that substance: but I could not determine its relations to my own satisfaction.]

6. Yellow ochre, of a duller hue than (3.) above; some Fuller's earth at the lower part.. about	0	4

	Ft.	In.
7. Under the ochre are irregular flattened ovoid masses, about 18 inches thick, consisting of stratified matter which contains shells. These masses were divided thus:— *a.* Thinly stratified, greenish grey, Fuller's earth, decomposed. The lowest part sometimes including thin seams of coaly matter, the remains, apparently, of highly compressed stems of plants; with fragments of shells. *b.* Thinly stratified, dark grey, alternating with lighter-coloured, sandy clay. Like the alternation which is frequent at the bottom of the lower green-sand, and in the Wealden, described above at p. 168. (83.)	1	6
8. Greenish matter, often stratified;—coarse Fuller's earth	3	0
[*Portland stone*:]—		
9. Whitish rubbly stone, not unlike freshwater limestone, but containing *Perna quadrata*, with ribbed and tuberculated Trigoniæ ..... 1 3 to	1	6
10. "*Pitching-stone**", consisting of—		
a. Hard compact grit: sand concreted by a very large proportion of calcareous matter .....about 0 9		
b. Fuller's earth, yellowish-green .....6 in. to 0 8		
c. Compact grit;—more siliceous than *a* 0 7	2	0
11. Grey clay, in about three layers	0	6
12. Limestone in two beds, including Pernæ .....about	2	6
13. "*White limestone*"; as below. *Pecten orbicularis* abundant.....3 ft. to	4	0

D.—At a pit on the south-west brow of Brill Hill, (a continuation downwards of beds above enumerated), the following is the order:—

(13.) "*White limestone*" (like the "*Chalk*" of Chicksgrove, 7. p. 253.) used only for making lime; sometimes harder and bluish. It occurs in irregular masses, and has the aspect of freshwater stone, but contains numerous *Trigoniæ* .....about	3	0
14. "*Cap of the Greys*". Brownish clay, full of fragments of shells		
15. "*Greys*". Good stone for building, full of Pernæ. Some of the beds contain stems, like those of Siphoniæ	1	0

Below the "Greys" are about 9 feet of alternate courses of indifferent stone and of yellowish grey sand, with Portland fossils—*Cardium dissimile*, *Pecten lamellosus*, *Trigonia gibbosa*. These are succeeded by sand charged with green particles, which, in the following list, is referred to the Portland sand; in which *Ammonites giganteus* is frequent, in some specimens with Oysters attached.

In some places here also, are erosions or cavities in the upper part of the stony strata, like the "Gulls" of Great Hazeley, (p. 276).

Portland Sand.—Good sections of this group are to be found in all directions around the village of Brill; in the descent of the hill from Long Crendon towards Thame; and on the north-east of the latter village.

Sections at Long Crendon, *and thence on the Descent towards* Thame.

One of the principal quarries at the upper part of the hill at Long Crendon exhibited the following beds:—

Tough loamy clay.....about	2	0

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* I have, in these lists, inserted the names in use among the quarrymen, as they may assist in identifying the strata in other parts of the country; the same pits seldom remaining open more than a few months.

		Ft.	In.
	[*Lower Greensand.*]		
1.	*a.* Ochre and ferruginous matter ..... 0 9 *b.* Dark grey clay ..... 0 4 to 0 9	1	6

These substances, as at Great Hazeley &c., vary much in thickness, filling up eroded cavities in the top of 2, next below.

[*Purbeck.*]

2. Rubble (the "Malm" of Garsington and Combe Wood); passing at the lower part into firm, slaty, cream-coloured limestone, in which green matter is diffused,—but not in grains; as in some of the upper Purbeck beds on the Dorsetshire coast.

3. Clay:—uniform, without the stony fragments of the Portland "Dirt." I could not learn that any petrified wood had been found here in this situation.

[*Portland stone.*]

4.	Stone, with Portland fossils, beneath which is sand ..... here about	8	0

[*Portland sand.*]

5. Below the foregoing beds, on the descent towards Thame, are,—

	a. Sand, with very numerous green particles, about 18 inches; enveloping coarsely concreted nodules, about 9 inches thick	2	9
	b. Rubbly, somewhat sandy, grey stone, with green particles,—like Kentish rag: under which are knobby concretions, of a marly stone with green particles, containing clavellated Trigoniæ ..... 12 0 to	18	0
6.	Greenish grey sand. At its junction with 5, and for about 6 or 8 inches downwards, are worn fragments of black flint; with Trigonia, Perna, and an oblong bivalve—a Panopæa ..... about	30	0
	The whole thickness of the Portland-sand here is about	50	0

7. Beneath is clay.

The greatest superficial extent of the Portland sand in this part of the country occurs near the village of Thame; extending from Scotsgrove and Scotsgrove Hill on the north, to Priest-end and Morton on the south; and from Dropshot, near Cotmore Walls, west of Thame, to the flat between the river and Long Crendon. The apparent range of the formation thence, by North Weston, Rycote, and Albury, to the heights above Wheatley, I did not examine.

Pit at Barley Hill, east of Thame.

The strata dip at an angle of about 5°, towards a point about 10° south of east.

1.	Soil and loam ..... 2 ft. 6 in. to 2 ft. 9 in.	2	6
	[*Portland Sand.*]		
2.	Irregular concretional lumps of calcareous stone with green particles, interspersed in sand. Petrifactions numerous:—Pernæ, with Lithodomi, and Ammonites; *Plagiostoma rusticum*, (near Towersey) ..... about	6	0

[This is evidently a continuation of the group at Long Crendon, on the opposite side of the valley of the Thame. It precisely resembles part of the cliff immediately north of La Creche, on the French coast near Boulogne.]

3.	Sand; becoming greener as it descends. At the top, few concretions of stone. At the bottom, the whole consists of greenish matter, not to be distinguished from that of the Lower green-sand near Folkstone. Serpulæ very numerous	1	0
4.	Coarse stone interspersed in sand; with numerous fossils, especially Ammonites, and *Trigonia gibbosa*	1	3
5.	More compact and uniform greenish or bluish rock, with green particles; like soft Kentish rag. In some of the quarries it is fit for building	1	0

	Ft.	In.
6. Sand; 30 feet (at least). The top only is visible here, but in other pits nodules of great size are scattered in it irregularly, close to the stone 5.....	30	0

These nodules are distinctly seen at an adjacent place called Dropshot. They are from 2 to 4 feet in length, and about 18 inches thick, and consist of large subglobular masses of hard, bluish green, sometimes highly calcareous, crystalline, grit, (here called "Bluestone"), like that of the concretions at Shotover. In some cases it is remarkable that they are flat at the top, while the form beneath is subglobular, (fig. 1. of the subjoined cut); pebbles of dark brown or black flint adhering to the upper surface, in a gravel-like crust. They are sometimes traversed by vertical cracks and veins, as in the quarries at Mont Lambert in the Boulonnois; and when broken, these exhibit flat surfaces,—as in fig. 2, which represents a large nodule, inverted, to show the form of the lower side*.

Fig. 1.

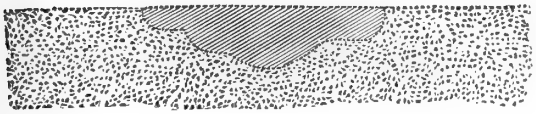
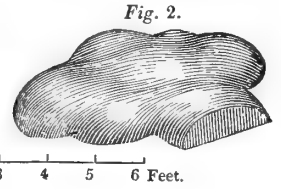
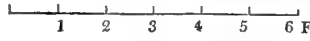


Fig. 2.





Muswell Hill.

This hill, which forms the extreme promontory of this range, was one of the principal Ordnance stations, and is 744 feet above the sea. The summit, I was informed, is composed of:—

1. *Lower green-sand.* Reddish sand, including concretions of a dark brown ferruginous conglomerate ("carstone"), which occurs also in large masses, and in thick beds, under a very reddish and ferruginous soil .....8 ft. to	10	0

[The *Portland stone* appears to be wanting here.]

2. *Portland Sand,* with green particles; Pernæ, Trigoniæ, Sphæræ, &c.

3. *Kimmeridge clay*: springs breaking out at its contact with the sands. No stone, I was informed, occurs between this place and Blackthorn: that which is employed in all the flat country on the south-west of the range, coming from Muswell Hill and Brill.

From Muswell Hill there is a fine view to the west and north-west, of the great plain occupied by the clays; and westward over Otmoor, which is crossed by a Roman road from Oxford to Bicester.

Oxford Oolite.—The stone of Blackthorn, about $3\frac{1}{2}$ miles west of Muswell Hill, is a variety of oolite or pisolite, consisting of oolitic grains disseminated through sparry limestone of a bluish colour.

(149.) Section, Pl. X. a. No. 20.—*From the Chalk near Wendover, through Aylesbury and Whitchurch in Buckinghamshire.*—The two great roads from London into Buckinghamshire cut through the chalk, one by the vale or defile of Amersham and Wendover, the other and more northern, by the Vale of Berkhampstead and Tring, the general altitude of which above the sea is about 350 feet; that of the adjacent heights of the chalk rising to

* *Fig.* 1. is intended to represent a vertical section of a concretional mass of stone imbedded in sand; of a subglobular or kidney-like form below, but flat at the top.

Fig. 2. is a sketch of another nodule, with a vein at right angles to the mass; through which a part has been broken off.

more than 600 feet. The summit level of the Grand Junction Canal at the opening of this vale to the north-west, is 404½ feet above the sea: and a branch of the canal is conducted at the same level along the foot of the chalk range to Wendover. The line of Section No. 20. runs from a point about two miles west of that town, above which Combe Hill, or (as it is called in the Ordnance Map) *Wendover Hill,* rises to 905 feet above the sea; and thence the ground descends rapidly towards Aylesbury, the height of that place being about 380 feet above the sea*, and a few feet above the flat occupied by the Kimmeridge clay on the north-west of the town. The slope and undulating ground from the chalk range to Aylesbury are occupied by the strata between the chalk and the Portland stone; and the corresponding tract, from Thame on the south-west towards Leighton on the north-west, which is emphatically called "the Vale of Aylesbury", consists of the same strata. The Portland stone forms a distinct ridge from Hartwell to Scotsgrove, on to the road from Aylesbury to Thame, of which the highest point near Dinton Castle is not much inferior in elevation to many parts of the chalk range. Between Aylesbury and Leighton the first rise of the Portland beds is obscured by accumulations of superficial gravel.

The Vale of Aylesbury in general has been lowered and levelled by the agency of water; but several detached portions of the beds between the Gault and the Portland stone, are still found on the higher parts of the ridge about Stone, and on the summits of the insulated heights beyond it. The strata seem to increase in thickness in approaching their outcrop, but this enlargement is probably no more than apparent, and produced by their better preservation near the most elevated points. If these places were once detached summits, or islands, in a shallow sea, of which the chalk escarpment formed the shore, the waves would naturally wear down and carry away the strata in the lower ground, while the portions above the reach of their action would remain.

(150.) The members of the series illustrated by the sections visible in this country, near to the line of No. 20, are:—1. The Lower green-sand; 2. The strata thence to the Portland-stone,—including some doubtful traces of the Hastings-sand, and the Purbeck strata; 3. The Portland stone itself, with the usual fossils; 4. In a few places, the Portland sand; 5. The Kimmeridge clay. The following details could not be arranged in exact succession, as portions of many different groups are frequently found in the same pits; but the ists are as far as possible disposed in the descending order of the strata, beginning with the Lower green-sand.

* The top of the church tower at Aylesbury is, according to Mr. Bevan, 425 feet above the sea.

Lower green-sand.—A considerable thickness of sand occurs at the top of the ridge above mentioned, in the space between Stone, Dinton, and Cuddington. It attains its greatest height near Stone, where there is a knoll apparently composed of sand; near which the following beds were found;—

Sand-pit at Stone.

	Ft.	In.
Vegetation and soil.....about 1 ft. to	3	0
1. Greenish clay, like Fuller's earth.....6 in. to	0	9
2. Grey sandy clay .....9 in. to	1	3
3. Rust-coloured sand, passing downwards into grey: the lower boundary is ill defined and irregular .....1 ft. 6 in. to	2	0
4. Whitish uniform sand, marked by nearly horizontal but irregular lines, of darker hue, grey, yellow, brown, and nearly black .....about	8	0
Total depth.....	15	0

Some remains of the Lower green-sand appear also at the top of most of the sections following, which are only a selection from a great number of lists. The series in all parts of the country is very nearly alike: but the pits being worked for the sake of the Portland stone, have not, generally, been opened in the places most favourable to the display of the superior strata.

The circumstance most deserving of notice in the sections at Ford, and thence towards Dinton, is the occurrence, near the bottom, of dark clay which includes a layer of iridescent Mytili, corresponding precisely in its character and situation to that at Bishopstone, Whitchurch, and other places hereafter mentioned.

Dinton Quarries.—One of the most remarkable quarries in this part of the country, is on the south-west of the cross-road from Dinton to Cuddington, where the works have been carried on for more than 200 years, the stone being of excellent quality. The Section was as follows:—

Stone-pits at Dinton.

All the beds inclining a little to the east.

	Ft.	In.
1. Vegetable soil, and reddish loam.....about	2	0
2. Ferruginous sandy loam	0	6
3. Greenish grey clay	0	9
4. Brownish and grey clay.....1 ft. 3 in. to	3	0
[The great variation in thickness of this bed arises from its entering at the bottom into the irregularities on the surface of 6. which are coated throughout with the intermediate thin bed of clay (5.)]		
5. Dark, umber-brown, tough clay, with much oxide of iron.....2 in. to	0	4
At the bottom of the bed are Mytili, and decomposed fragments of other shells.		
[*Purbeck Strata.*]		
6. Grey clay and soft stone (freshwater limestone) becoming white at the bottom by decomposition: at the lower part more continuously laminated, but including throughout irregular masses of stone, in some places penetrated by minute tubular cavities, slightly bent and of uniform diameter,—probaby the work of lithophagous animals, or such as might be produced by the removal of slender twigs. The decomposed parts of this stratum pass into the firmer masses; as in the "Malm" of Garsington. It contains a few spiral univalves like those of that place and Combe Wood, including *Paludina* (*elongata*?), with small Modiolæ, and a Cyclas? ..... (3 feet thick in an adjacent pit)....	3	0
7. Between 6. and 8. is a thin bed of tough, dark, somewhat ferruginous? clay, with iridescent Mytili (*M. Lyellii*?) at the bottom		

	Ft.	In.
8. Whitish beds of nearly uniform aspect.		
a. Soft fissile marl or limestone in about six beds; the divisions, however, seem to be the effect of decomposition ..... 3 ft. to	4	0
b. Uniform hard grit or sandstone, consisting of quartzose sand in a calcareous cement	1	0
	5	0
9. Stony concretions, in greenish very fissile sandy clay;—3 to 5 beds; passing into, and continuous with 10	1	0
10. Fissile sandy matter; and grey, sandy clay, passing into 11	1	6
11. Fissile, tough, yellowish, sandy clay, containing much calcareous matter, and including Cypris, Mytili, and Modiolæ		

[*Portland Stone.*]

12. Beds of good stone; grey without, blue within.
    - *a*. "*Capping*," full of shells; like the "Roche" of Portland ..... 8 in. to 0 9
    - *b*. Solid stone, the best .....
    - *c*. Soft stone, bluish, full of remains of shells; *Ammonites giganteus*; *Exogyra nana*; Ostrea, two species; Plicatula .....

Bottom of the Quarry .....

The proportion of sand to the stone, in these quarries, is much greater than in those of the coast, the Portland stone here appearing generally in the form of concretions in the sand: and this is the case also in the Boulonnois. Near Dinton Castle the stone assumes the form of insulated, subglobular, or potatoe-shaped concretions, containing great numbers of Oysters, with other fossils.

(151.) One of the most prominent circumstances in the upper part of the preceding sections, is the contrast between the arrangement of the sands and Fuller's earth, or ochreous clay, and that of the beds which represent the Purbeck formation immediately below; the upper surface of the latter being commonly indented or eroded into cavities and inequalities, from a few inches to four or five feet in depth, which are generally coated with a thin stratum of clay, and then filled up with sand and gravel. These appearances, which are perfectly analogous to that represented at p. 276, in the cut of the "Gulls" of Great Hazeley, and to the discordance of the two sands at Swindon, p. 265, are observable in all the pits of this country. They clearly show that an interval must have elapsed between the deposition of the Purbeck strata and that of the Lower green-sand, during which the surface of the former was disturbed, by the operation no doubt of water.

(152.) The tough clays, near the junction of the incumbent strata with the Portland beds, are well seen in many of the pits of the lower country, as at Bishopstone and Southwarp, and in the heights about Whitchurch and Quainton. It is difficult or impossible, in some cases, to determine whether they are to be referred to the Fuller's earth of the Lower green-sand,—to some of the beds subordinate to the Weald-clay and Hastings-sand, or to the Purbeck series. But it may be remarked that, although these clays alternate with thin slaty limestone, which contain Cypris and other freshwater fossils,

no bed strictly resembling the "*Black Dirt*" of Portland has yet been found here,—none including, like that bed, fragments of *stone*, and exhibiting so obviously the characters of a coarse gravelly soil: nor have I seen or heard of any instance north of Garsington, in which silicified wood has been found in this part of the series. It can only be said, therefore, that the beds above the Portland here resemble those of the coast, in their sudden contrast with the Portland strata, from the abundance of the freshwater fossils which they contain, and the frequent alternations of beds of clay, or mud, with the fissile limestone near the contact.

Pit at Bishopstone :—*in "Church Furlong" belonging to Dr. Lee.*

	Ft.	In.
1. Soil bearing corn.		
2. Fuller's earth; greenish and brown. Thickness very irregular.....1 in. to	1	0
In this bed are iridescent Mytili, like those of the bed 7. below, and of the sections at Whitchurch; p. 288—289.		
3. Rubble; white, freshwater limestone, decomposed: containing Cypris and casts of small Paludinæ, in calcareous spar	4	0
4. Clay and stone.		
a. Light olive greenish Fuller's earth 0 4		
b. Soft limestone 0 6		
c. Fuller's earth, like *a*..... 0 2		
d. Stone, like *b*..... 0 3		
e. Fuller's earth 0 2	1	5
5. "*Sandstone*", so called; firm, grey, and whitish, granular calciferous grit. It has distinct traces of the lines of deposition, and on the surface some approach to ripple-marks. —*Quæ.* does it represent the grit of the Hastings sands?.....6 in. to	0	9
6. Sand, alternating with ochre and clay.		
a. Sandy ochreous clay 0 2		
b. Dark greenish Fuller's earth 0 2		
c. Greenish grey sand, mixed with calcareous matter, and including scales of fishes 0 7	0	11
7. Fissile, calciferous clay, or marl, passing into stone. In the upper part are iridescent Mytili (*Mytilus Lyellii*? Pl. XXI. fig. 18.) like those of 2. above, and of the pits near Whitchurch.		
a. Dark, bluish grey, very fissile clay, containing *Cypris* in great numbers, an oblong Unio, and small scales of fishes (Lepidotus).	1	6
b. Clay; somewhat harder, less plastic.		
c. Clay; lighter-coloured and still harder; approaching to stone.		
All these divisions contain *Cypris Valdensis* and another species; a small smooth Modiola, a striated species; and *Cyclas parva*, Pl. XXI. fig. 7.		
[*Purbeck.*]		
8. "*Pendle*": fissile, argillaceous limestone; here of a dark grey colour; in another adjacent pit almost white: containing Cypris; casts of *Cyclas parva*, some of which include casts of Cypris; striated Modiolæ; small Paludinæ; and other small univalves, as in the Malm of Garsington ..... 4 in. to	0	6
In some of the pits hereabouts, the "*Pendle*" contains also a depressed Planorbis, as		

at Wockley in the Vale of Wardour, 5. *b.*, p. 252., and at Garsington, 3. *c.*, p. 277.; with *Potamides carinatus*?.

[*Portland.*]

9. "*Bottom Rock*". This, in one of these pits, is an agglomerate of fragments of shells; of a dark bluish hue, specked with white. In an adjacent pit it abounds in Trigoniæ and other Portland fossils.—Thickness not ascertained.

The beds below are not visible, and are unknown to the workmen.

The upper part of several other pits near Bishopstone (as at Southwarp and the vicinity of Dinton,) agrees with the foregoing list, in exhibiting an alternation of clay, more or less like Fuller's earth, with ochre and ferruginous sand: and the very dark clay which includes iridescent Mytili, occurs in so many places that there can be little doubt of its former continuity throughout this part of the country. It is particularly distinct on the side of the road from Whitchurch to Winslow, near the turn towards Dunton, about eight miles from Bishopstone; where, besides the usual Mytilus, it contains a Natica and another spiral univalve (Melanopsis?). Beneath these clays and sands is, universally, thin slaty marl or limestone, with alternate thin beds of clay, containing everywhere the same fossils;—Cypris, Modiolæ, and spiral univalves,—among which are Paludinæ, a Planorbis, and perhaps some other species. The whole group, therefore, clearly represents the strata above the Portland stone at Garsington, and in the Vale of Wardour; and is, no doubt, the equivalent of the "Slate", the "Cap", the "Dirt", and the other lower beds of the Purbeck formation, on the Dorsetshire coast.

Pit near Whitchurch :—A. (*Denchfield's.*)

(Compare with the Section at Quainton, p. 289—290.)

		Ft.	In.
1.	Grass, over vegetable soil ..... about	4	0
	[*Lower green-sand and Wealden.*]		
2.	Greenish white, coarse, sandy clay; including rounded pieces of sandy stone.....	7	0
3.	*a.* Tough, grey, and greenish clay; including *b.* .....about 0 9		
	b. A dark band of very tough clay .....about 0 6		
	c. Clay, like *a.*; the lower surface waved and irregular. This, at its junction with the darker clay above, and for a short distance below, is full of a thin iridescent Mytilus, so fragile that I could obtain only very imperfect specimens 0 9	2	0
4.	A group, which my guide called "*Cornstone*?".		
	a. Grey and greenish sand, irregular in thickness.....4 in. to 0 9		
	b. Whitish clay, sand, and soft stone 1 5		
	c. Tough, grey, and brownish clay, passing into *d.*..... 0 5		
	d. Similar clay, including concretions of gritty stone .....about 1 0	3	6
5.	"*Green-stone*", (so called), comprising,—		
	a. A thin bed of hard, brownish clay, like part of 3. above.....1 in. to 0 2		
	b. Fissile sandy clay, greenish grey .....4 in. to 0 5		
	c. Hard calciferous gritty stone, in irregular concretions..... 0 4		
	d. A band of yellowish grey soft sandy clay or marl .....about 1 0	2	0

The calciferous grit, 5. *c.*, which is like that of Bishopstone (5. p. 287.), and of Quainton (9. p. 290.), deserves notice, from its resemblance to the grit of the Hastings sands: and it contains at Quainton casts of a spiral univalve,—Paludina (or Natica?).

[*Purbeck.*]

6. "*Heath*". Green and grey sand, of firm consistence; at the bottom mixed with whitish fissile matter .....

7. An indistinct bed of soft fissile limestone ("*Pendle*", my guide calls it), which seems to pass below into very hard stone, including Cypris and worn ovoid particles of whitish stone. It contains also small bones and scales of fishes .....

8. The beds below 7. are here uncertain; but are visible in some other pits.

The Portland strata here, in general, differ from those of Portland Island and of Dorsetshire; no thick beds of good stone occurring, and no flints.

I saw here no traces of silicified wood, nor of Cycadeæ, though I examined everywhere the beds of clay, with the hope of meeting them.

In another pit near Whitchurch the lower beds were visible, the whole being thus:

Pit near WHITCHURCH :—B.

Rubble.

[*Weald Clay, and Hastings Sand?*].			Ft.	In.
1. Stony matter, much decomposed			4	0
2. Dark brown and grey tough clay, with some layers of sand, including Mytili			1	0
3. "*Cornstone*"; (see 4. of the preceding list)			0	2
4. "*Cheesecakes*"; clay in very thin flakes, alternating with sand. (Compare with the alternation described in (83.) p. 168.)			0	4
5. Rubble and sandy stone			0	10
6. "*Greenstone*"; concreted sand, and grit, like that of Hastings?—(See 5. *c.* List A. last page.).....		6 in. to	9	0
7. "*Firestone*"; soft limestone			0	10
8. *a.* Sand; uniform, greenish-grey, coherent.....	1	6		
b. Dark clay	0	2	1	8

[*Purbeck Strata.*]

9. "*Pendle*"; soft fissile limestone, including worn rounded particles of stone, which give to the whole the aspect of oolite; and containing Cypris; Modiola, two species; a Mytilus; *Cyclas parva*; and portions of an Astacus			1	6

[*Portland.*]

10. Limestone; often bluish, abounding in Trigoniæ, Venericardia, and other Portland fossils.....			0	9
11. Good stone, called "*Builders*";—often bluish.....			2	6
Bottom of the Pit.		Total about 10 ft. to 12	0	

Pits at the top of QUAINTON HILL,

About a furlong east of the Ordnance Station, which is 754 feet above the sea Beds inclined towards the south at about 3° 30′.—See the Transverse Section, Pl. X. b. fig. 10.

[*Lower greensand, and Wealden?*].				
1. Red sand, with concretions of hard ferruginous conglomerate; ochre at the bottom:—		visible about	2	0
2. *a.* Clay and sand; brownish and grey, in thin alternating flakes ....about	1	6		
b. Fuller's earth; wax-like, as at Brill, (4. p. 280.)	0	9	2	3

		Ft.	In.
3.	White, and brown, sand and clay	0	9
4.	Alternate beds of white, reddish, and yellowish sand, and thin courses of grey clay 4 ft. to	6	0
5.	*a.* Dark brown clay, called here "*Black Dirt*" ..... about 0 4 *b.* Alternate beds of tough grey clay and sand 1 0	1	0
6.	Greenish sand, said to be 6 feet thick	6	0
	Total ..... about	17	0

The beds next below are obscure, from subsidence: the order was stated to be as follows:—

7.	"*Black-dirt*"; tough dark clay	0	3
8.	"*Grey dirt*"; grey sandy clay, with fragments of shells ..... about	6?	0
9.	"*Hard stone*", consisting of siliciferous grit or sandstone; containing *Paludina elongata*? and Cyclas?. Has been found in masses 5 feet thick 15½ feet long: used for paving roads (*Quæ.* the grit of the Hastings sand?)	3	0
		26	3

The following, still lower than the beds above detailed, are seen in another part of the hill, under red sand and hard ferruginous conglomerate, (*carstone.*)

[*Purbeck.*]

10.	"*Heath*"; white sand and clay; full of decomposed shells in layers;—Mytilus; striated Modiola; and Cypris	3	0
11.	"*Pendle*". Fissile oolitic stone, containing Cypris, *Cyclas parva*, Mytilus, and Modiola;—as at Dallard's, in the Vale of Wardour, pp. 249, 250	0	6

I did not see any remains of trees, or of Cycadeæ, in these quarries, nor hear of any from the quarrymen. But among the specimens which I obtained in the village of Quainton, said to have come from the hill, was that represented in Pl. XXII. fig. 11, which possibly may have been part of a Cycadeous plant?. The specimen however, differs both from the trees and Cycadeæ of the Dorsetshire coast, in being calcareous, effervescing copiously with acids.

The following beds were seen best in the eastern pits, near the Ordnance Station,—

[*Portland.*]

12.	"*Builders*" limestone, fit for building, containing *Pecten lamellosus* and small Modiolæ ..... 2 ft. 6 in. to	3	0

Among the Portland fossils from the quarries of Quainton Hill which I saw in the village was an Ammonite 18 inches in diameter, with a Belemnite imbedded in it.

13.	"*Limestone*", full of petrifactions; *Trigonia extensa*, *T. gibbosa*, *T. incurva*; *Pecten lamellosus*, with Gastrochænæ; Pleurotomaria ..... 5 ft. 6 in. to	6	0
14.	Sand ..... about	6	0
15.	"*Middle Rock*", and Rubble; stone abounding in fossils	5	0
16.	Sand	2	0
17.	Greenish concretional stone, rugged and sandy ..... 1 ft. 6 in. to	2	0
18.	"*Bottom rock*", greenish gritty limestone, with stems of Siphoniæ. The pits are never dug lower.		

The *Portland stone* as it approaches the outcrop in this part of the country, becomes much more sandy at the lower part, and seems to pass into the sand beneath. The quarries on the north-west of Whitchurch, towards North Marston, include, between two beds of stone, a stratum of uniform grey sand, eight feet thick; which preserves its thickness, and is well known to the quarrymen in other parts of the adjacent country. The stone is worked (and perhaps exists) only in a few places on the north and east of Whitchurch; but from its extensive occurrence at

Church Farm on the west of Wing,—and again at North Tinkershole south of Stewkley, on the north of Dunton, and west of Hogstone,—it would seem that the upper part of most of the flat-topped heights thereabouts may have once been occupied by this formation*.

The Portland strata also occur at Weedon on the south of Whitchurch, about midway to Bierton, the western part of which village stands upon them. But I was assured that no stone had been obtained, though often sought for, at Cublington, Aston Abbots, and Wingrove; the two places last mentioned affording only sand and gravel†.

The *Portland sand* is little disclosed near Aylesbury; though it comes to the surface around the town beneath a thin capping of Portland stone. The road from Tring to Aylesbury, a little west of the 37th milestone, is crossed by sand, which includes green particles and worn fragments of black flint; and the subjacent clay makes its appearance close to Aylesbury on the north. One of the most distinct sections of the sand was visible at the entrance of Whitchurch, where the road to Aston Abbots strikes off from the main. A good section also was obtained from combining that of one of the pits at the Warren near Tinkershole on the south of Stewkley, with another north of Dunton.

Whitchurch, at the cross-road to Aston Abbots.

[*Lower green-sand?*]

1. Yellowish sandy soil.
2. Greenish and reddish sandy clay.

[*Portland Sand.*]

	Ft.	In.
3. Concretional soft stone, in irregular lumps, full of green particles; with numerous shells; Venericardia, Pernæ. Compare with that of the Section near Thame; 2. p. 282. ..	4	0
4. Harder stone, in irregular concretions, abounding in green particles, and containing worn fragments of blackish flint or chert. Very large specimens of *Ammonites biplex*, as on the shore near La Creche, Boulonnois; *Pecten concentricus*; large Venericardia.....		

[*Kimmeridge Clay.*]

5. Dark bluish clay, continuous with that of the descent towards Hardwick, and thence to Aylesbury; here dug to the depth of about 20 feet, and used for making tiles. It contains Septaria, and nodular masses of phosphate of lime,—which, when acted upon by marine acid, afford the peculiar smell of Coprolite, though they have not its form. Among the fossils here are channelled Belemnites.

Pit at The Warren, south of Stewkley.

Soil and whitish rubble.....about			2	0
[*Purbeck.*]				
1. *a.* Light yellowish grey clay, passing into stone	1	0	1	9
b. Rubbly limestone.....	0	9		
[*Portland Stone.*]				
2. Soft, uniform, marly limestone, abounding in fossils;—*Ostrea expansa*; *Pecten lamellosus*, *Buccinum naticoïde*, Pl. XXIII. fig. 4, *Perna quadrata*, Pleurotomaria, Trigoniæ, Venericardia, and large Ammonites .....4 ft. to			6	0

* *Moor Hill*, a height about a mile and a half north-west of the village of Quainton, has a nearly horizontal top; and, not improbably, is capped with Portland stone or sand.

† Smith's map of Buckinghamshire represents the *Gault* as extending to the north-west from between Hulcot and Wing, as far as Cublington and thence to Cottesloe. If this be correct, the Portland beds may exist within that space, at a depth below the surface at least equal to the thickness of the Lower green-sand in this part of the country: but the map near Aylesbury requires much correction.

	Ft.	In.
3. Uniform, yellowish-grey sand; precisely resembling that which includes the stone called "Les Grises" in the quarries near Boulogne.....visible about	7	0
[*Portland Sand.*]		
4. Hard, dark brownish-grey stone, of irregular thickness, containing Pernæ. Approaching to the nodules of Shotover.....	2	0
Bottom of the Quarry.		
5. Below is green matter, used to form the floors of barns; not visible here at present, but well seen near Dunton.		

In a pit at *Dunton*, the equivalent of the bed 3. is only three feet thick; and that of 4. consists of rubbly calcareous stone, alternating with sand, the whole full of green particles, with small pebbles of black flint,—at the bottom of which is a continuous bed of greenish stone, about 2 feet thick, with dark particles, containing large Ammonites, *Perna quadrata*, and many other fossils. The equivalent of 5. is tough green matter, apparently the same with that which gives the greenish hue to the stone. This has been dug to the depth of about 3 feet.

Kimmeridge Clay.—This clay is sufficiently characterized, at several points near Aylesbury, by its occurring immediately beneath the Portland sand, and by its fossils. On the north-west of the town, towards Bierton, it appears beneath about five feet of brownish sandy clay,—(Portland sand?,) which includes numerous fragments of flint; and it contains Septaria, with Ammonites. The tiles made of it are of a full red colour. Thence to the entrance of Whitchurch on the south, the road appears to be cut wholly in the clay: but there are variations in the hue of the beds exposed along the road, and perhaps some alternating layers of sand. In descending to the streamlet south of Hardwick, were iridescent fragments of shells, with *Gryphæa* (*Exogyra*) *virgula*, (Pl. XXIII. fig. 10), and Aptychus, (Pl. XXIII. fig. 11), in the ditches at the road-side. At Quainton, clay forms the slope of the hill beneath the stone-pits; and a well had been dug, at the village, in clay, to the depth of 60 yards; among the fossils brought up from which, were beautiful specimens of *Ammonites Gulielmi*, like those obtained, along with *A. biplex*, from East Claydon, about three miles north of Quainton, where they were found about 20 feet deep in clay.

The clay-pits beneath the hill at Stewkley, about midway between that village and the Warren above mentioned, also afford Aptychus, and *Exogyra virgula*; with compressed Ammonites of the Kimmeridge clay, and a species supposed to be new.

(153.) *Section No. 21,—from Dunstable through Hockliffe to Woburn;—and No. 21′, Hockliffe to Fenny Stratford.*—The tract occupied by the strata below the chalk, from Aylesbury to the coast of Norfolk, is even less known geologically, than that between Buckinghamshire and the south-eastern coast; the maps of Mr. Smith and Mr. Greenough, and the general description of Messrs. Conybeare and Phillips being the only publications relating to it. The want of correct maps would alone have prevented the complete examination of this district; but this impediment will soon be removed by the completion of the Ordnance Survey from Bedfordshire to Cambridge. The following observations indicate only some of the more prominent facts connected with the beds below the chalk.

The series of strata in Sections 21 and 21′, differs from that of the preceding sections, principally in the absence of all the beds between the lower greensand and the Kimmeridge clay, which are found in immediate contact, at the village of Little Brickhill, on the brow of the descent to Fenny Stratford:—this junction, which was to have been expected hereabouts, from the evident thinning out of the Purbeck and Portland formations in the north-east of Buckinghamshire, is continued thence, through Bedfordshire, into Cambridgeshire, and even to the coast of Norfolk.

The great accumulation of gravel and transported matter, rising in several places into hills and extensively concealing the strata, is another circumstance which distinguishes the vicinity of Leighton Buzzard from the country towards the south-west, and renders the examination of the strata difficult or impracticable. A similar coating of gravel is found not only throughout Bedfordshire, and a great part of the counties on the north-east of it, but far to the east of the chalk escarpment itself*. The fossils, and stony substances, which compose this deposit, have been derived from many different formations, some of them very remote, and are deserving of attentive examination. My collection includes only a few specimens from one of the ravines which descend from Little Brickhill, and from the Platform between Stewkley and Soulbury, about 510 feet above the sea, where the multifarious gravel includes fragments of granite, and a large proportion of chalk. This deposit does not there form an escarpment, like the sands at Brickhill, but declines gradually towards the north, in a series of lower inequalities: on the south and east, it occupies a great part of the surface towards Leighton, Wing, and Cublington.

On the line of the Section, No. 21, the ridge of the chalk attains nearly the greatest height which it anywhere exhibits,—Kensworth Hill, south of the road near Dunstable being 904 feet above the sea; but the general elevation and that of the principal summits both rapidly diminish towards the north-east. Near Tring, the difference in height of the upper and lower chalk escarpments is strongly marked; and the retreat of the former is still more conspicuous near Dunstable; but the boundary of the lower chalk is less distinct.

The Upper chalk forms the elevated range from the Five Knolls, and Kensworth Hill, 904 feet, by the heights above Zouche's Farm, 850 feet, towards Luton, and thence to Whitehill Farm, on

* At Muswell Hill, on the north of Highgate in Middlesex, an accumulation above the London clay, includes worn fragments of granite, porphyry, micaceous sandstone, mountain-limestone, coal, lias, and chalk, with many of the characteristic fossils of those formations: the chalk especially being so abundant, as to give the whole a chalky character.—Mr. Spencer, in *Proceedings of the Geol. Society*, 1835—6; vol. ii. p. 181.

the north of that village, and Lillihoe in Hertfordshire, an Ordnance Station 604 feet above the sea.

The Lower chalk, on which the village of Dunstable is placed, runs from Totternhoe on the south-west of the main-road, through Houghton Regis, Upper Sundon, and Streatley, on the north-east of it.

On the north-east of Totternhoe mines are driven into the hill at the bottom of the chalk, for the purpose of extracting a bed of uniform light greenish-grey, marly and sandy, firestone, from seven to ten feet thick. The strata are traversed by numerous cracks, which seem to pervade the hill, and indicate disturbance,—or perhaps the effect of subsidence.

The Gault, in Smith's map of Buckinghamshire, occupies a large part even of the higher ground between Whitchurch and Wing. The Lower green-sand runs out without interruption from Whitchurch to Winslow, and is continued thence by Drayton, Parslow, and Soulbury, to the south of Leighton. On the north of that line, a denudation on the course of the Little Ouzel river having cut down to the subjacent clay, breaks in upon the outcrop of the sands, which would otherwise have been continuous from Winslow to Brickhill, and the mass of the Woburn sand-hills. Beyond the two tracts at present continuous, several outlying patches of sand, some miles distant from each other and from the general escarpment*, are ascribed to this formation in the map; all of which, as well as the wider tract between Winslow and Leighton, deserve examination, for the purpose of ascertaining whether any of the Wealden beds are to be found there.

The greatest expanse of the Lower green-sand in the midland counties, occurs between Leighton and Ampthill in Bedfordshire; rising, at the Ordnance station on Bow-Brickhill, to the height of 683 feet above the sea,—or about 430 feet above the lowest point in the valley on the west of the escarpment near Fenny Stratford. One of the most remarkable subordinate beds of the formation in this neighbourhood, is Fuller's earth, which, when I was there (in 1824) was brought out by mining from the north-west escarpment of the sand-hills, near Hogstye-end, between the main road from Woburn to Northampton, and that from Hockliff to Stony Stratford.

Fuller's earth Pit, near Woburn.

	Ft.	In.
1. Sand; nearly uniform, greenish-grey, and yellowish, including consolidated masses of sand-rock, and dipping to the east and south. .....about	130	0
2. *Fuller's earth.*		
a. "*Top*" of inferior quality; not diffusing itself in water till after it has been dried: unfit for the purposes of the clothier 3 0		
b. Ferruginous? clay .....about 0 1	12	0
c. Fuller's earth, of the best quality, very light olive green; (sold at the pit-mouth to cloth-manufacturers, for one shilling per cwt.) ..7 ft. to 9 0		
4. "*Bottom*"; hard quartz or sand-rock; the equivalent, probably, of the chert of the Kent and Surrey sand-hills.....2 ft. to	2	0
5. Sand, like 1; thickness not ascertained.		

The Geological place of the Fuller's earth is here, therefore, nearly the same with that of

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* These outliers are represented on the Buckinghamshire map by patches of colour, each about half a mile in diameter, at Roundhill, Whaddon, Totternhoe, Wroughton, Milton-Keynes, Broughton, Moulsoe, and Astwood. In Mr. Greenough's map, (1st edition,) both Winslow and the heights of Whadden Chase on the north of that town form a portion of the tract coloured as Oxford clay; but this, no doubt, requires correction.

Nutfield described above (141.); which, however, is thicker than this of Bedfordshire, and is continued through a much larger space. I did not find here any of those nodules of sulphate of barytes, which are frequent in the earth of Nutfield; and in neither of these two situations, does this bed contain the great number and variety of fossils by which the Fuller's earth at the bottom of the Lower green-sand is distinguished, at Atherfield in the Isle of Wight. In the sands of this part of Bedfordshire silicified coniferous wood is frequently found in large detached pieces.

These pits have continued to supply Fuller's earth for more than a hundred years. They were described, in 1723, by Dr. Holloway, in a letter to the celebrated Woodward, which is remarkable in the earlier history of stratigraphical geology in England*: the author pointing out the parallelism of the range of sands, to that of the chalk in the Chiltern hills, and suggesting distinctly, upon geological grounds, the probability that other portions of the sand range would afford the same valuable material; which, we have seen, coincides with the result of modern investigation.

The junction of the Lower green-sand and the Kimmeridge clay at Little Brickhill, (Section 21′) occurs at the north-west end of the village, in the garden of a small public-house called the King and Queen, on the south of the road. Copious springs break out on the road about 50 paces above this house. The clay, which is here of a dark blue colour, includes very fine specimens of an *Ostrea deltoidea*, with Belemnites; and I was told that sand alternates with the clay for a short distance below this point.

(154.) *North-east of Bedfordshire.*—The Lower green-sand, according to Smith's map, passes through the whole of this county, in a band which is in general parallel to the chalk escarpment, and about five miles in width; but its apparent dimensions vary much, in consequence of the irregular encroachments of the gault over the surface; that stratum, immediately on the north of Section 21, extending northward from the little village of Heath, through Potsgrove and Froxfield, to Steppingley and Flitwick. Again, on the east of Ampthill, an insulated portion of clay, (the colour of which, in Smith's map, is intended either for Gault or Kimmeridge clay,) stretches in a north-eastern direction from around Maulden to South Hill, crossing the great London road to Bedford, about the 43rd milestone. Since, however, the full development of the Lower green-sand in Bedfordshire renders it probable that the subdivisions of the Kentish coast may be found also in this country, it may deserve inquiry whether some of these detached portions, which have been considered as clay,—(especially between Maulden and South Hill) may not belong to the middle, dark-coloured, and retentive member of the sands; and the same question may be applied to a part, at least, of the remoter tract assigned by Smith to the Gault, on the north of Hockliff.

* This document has been inserted in Conybeare and Phillips's "Outlines", p. 138-9. Dr. Woodward himself speaks almost poetically of the value of the English Fuller's earth; which, he says, is beyond that of the Diamond mines of Golconda, &c.:—Edinb. Rev. 1819, vol. xxix.; and London and Edinb. Phil. Mag. 1832, vol. i. p. 155.

The course of the upper chalk is prominent on the north of east, from Dunstable through Hitchin and Baldock, to Royston Down in Cambridgeshire, which is 464 feet above the sea: but the boundary between the lower chalk and the strata next below is not distinctly indicated by the external features of the country. The change occurs on the main road from London to Bedford, between Hitchin and Shefford, about the 37th milestone: and there the difference in the elevation and general appearance of the ground is very slight; in part from the very gradual rise of the strata, but chiefly from the general diffusion of a coating of transported materials, which conceals them.

(155.) *List of Fossils from the Beds between the Chalk and the Oxford Oolite, in part of* Oxfordshire, Buckinghamshire, *and* Bedfordshire.

[*Superficial Gravel.*]

Ammonites (fragments). Chelsey, near Leighton, Bedf. (From the Gault?.)
Belemnites minimus? (fragments). Stone Lane, north of Heath, Bedf.
B———. Gravel-pit north-east of Stewkley, Bucks: with fragments of chalk; top of the high grounds, Brigginton, &c., near Leighton, Bedf.
Gryphæa dilatata (much worn.) Gravel-pit north-east of Stewkley, Bucks.
G——— (fragments). Stone Lane, north of Heath, near Leighton, Bedfordshire.
G——— obliqua (much worn.) Gravel-pit north-east of Stewkley.
Ostrea deltoidea (fragments). Stone Lane, north of Heath, Bedf.
Serpula. Gravel-pit, north-east of Stewkley.
Terebratula. In rolled piece of sandy limestone. Gravel-pit north-east of Stewkley.
Spongia? Flint, enveloping Sponges?: worn. (No doubt from the upper chalk.) Gravel-pit north-east of Stewkley.

[*Lower Chalk and Chalk Marl.*]

Ammonites lautus. In pale marly clay (chalk marl). Tetsworth, Oxf.
Terebratula semiglobosa. Tetsworth, Oxfordshire: in flint.

[*Upper Green-sand.*]

Inoceramus. Between Tetsworth and Thame, Oxf.; with Vermetus, in bluish grey firestone.
Mytilus (new species?). Between Tetsworth and Thame: in soft gritty firestone.
Siphonia. Impressions of stems. Totternhoe, Bedf.
Vermetus. Between Tetsworth and Thame: with Inoceramus; in bluish grey stone.

[*Gault.*]

Ammonites decipiens. Compton, Bedf. Mr. Goodhall.
Avicula. Compton, Bedf. Mr. Goodhall.
Crenatula. Compton, Bedf. Mr. Goodhall.

Exogyra conica. Compton, Bedf. Mr. Goodhall.
Inoceramus sulcatus. Compton, Bedf. Mr. Goodhall.
Nucula. Compton, Bedf. Mr. Goodhall.

[*Lower Green-sand.*]

Siphonia, Casts of stem. Quainton pit, east of Ordnance Station: in the "Bottom rock."
Wood, Coniferous, silicified. Woburn Sands, Bedf.

[*Hastings Sand?.*]

Cyclas, impressions of. Quainton, Bucks: pit at the highest part of the hill in grey calciferous grit, "Hardstone."
Paludina elongata? Impressions. Same place and situation.
Serpula?. Coney Hill, Bucks. In grey uniform grit,—"Sandstone".

[*Purbeck Strata.*]

Astacus?. Whitchurch, Bucks. In freshwater limestone, "Pendle", with worn particles like oolite.
Astarte. Same place and situation.
Cyclas media. Hartwell, Bucks; with *Modiola.* Whitchurch; with *Cypris Valdensis.* Weedon; in stone like the "tilestone" of Ladydown, and the "slate" of the Isle of Purbeck.
C—— elongata. Whitchurch, Bucks.
C—— parva. Horton's Pit, near Bishopstone, Bucks; in slaty soft limestone. Bishopstone (Dr. Lee's pits) in soft bluish stone. In great numbers at Weedon, in the "Pendle". Whitchurch; impressions in freshwater limestone, with worn rounded particles. Quainton; Western Pit, in the "Pendle".
C—— (a large species). Quainton, West Pit. Whitchurch, Bucks. Haddenham, Bucks: in slaty limestone. Garsington, Oxf.: in the "Malm".
Cypris Valdensis?. Whitchurch, Bucks. Bishopstone, in soft bluish shale, Quainton.
C—— (species uncertain). Combe Wood, and Garsington, Oxf.: in the "Malm"; with *Paludina elongata.* Denton, Bucks: in slaty soft clay. Weedon; in stone like the "*Tilestone*" of Ladydown, and the "*slate*" of Purbeck. Ford, numerous. Horton's Pits, Bishopstone in sub-oolitic; stone: and in soft bluish slaty stone, at Dr. Lee's pit. Southwarpe. Quainton. Whitchurch.
Limnæa?. Garsington: in the "Malm",—the representative of the "Cap" of Portland.
Melanopsis?. In dark-brown clay above the Portland strata. Road from Whitchurch to Winslow.
Modiola. Remains of two or more species, one deeply striated. Garsington and Combe Wood, Oxfordshire: in the "Malm." Hartwell and Bishopstone, Bucks. Southwarpe: in soft fissile limestone. Whitchurch. Quainton: a small species in tough sandy clay: in the bottom of the "Heath", over the "Pendle".

Mytilus Lyellii? Pl. XXI. f. 18. Bishopstone: Dr. Lee's pit. Near Whitchurch, on the road to Winslow: numerous; in light greenish grey, alternating with dark, tough clay, over the top of the Portland strata.

M——. Another species, smaller and narrower than *M. Lyellii*. Combe Wood, "Malm". Dinton, Bucks. Bishopstone. Horton's Pit; in slaty soft limestone. Dr. Lee's pits. Weedon. Whitchurch. Quainton.

Ostrea expansa. Horton's Pit, Bucks. (*Quæ.* in Portland-stone?)

O—— (thin-shelled). Combe Wood: "Malm".

O—— (fragments of another species). Whitchurch, Bucks; in the "Pendle." Garsington, Oxfordshire: "Malm".

Paludina elongata. Combe Wood, and Garsington: in the "Malm"; casts, with Cypris. Southwarpe, Bucks. Bishopstone, pit near Morton's.

P——. Impressions of another species? Southwarpe, Bucks. Horton's Pit: in freshwater limestone. Quainton: in the grey uniform grit; *Quæ.* Hastings sand.

P—— (a ribbed species). Garsington and Combe Wood, Oxfordshire: in the "Malm".

Planorbis. Garsington and Combe Wood, Oxfordshire: casts in the "Malm"; Horton's Pit, near Bishopstone, Bucks.

Potamides carinatum. (Melanopsis, Min. Con.) Horton's Pit, Bishopstone, Bucks.

Psammobia?. Garsington: "Malm".

Unio. Bishopstone, Dr. Lee's Pits: in soft bluish slaty stone. Quainton.*

Fishes. *Bones*; impressions only. Southwarpe, Bucks: in soft earthy fissile limestone.

Vertebræ. Whitchurch, in freshwater limestone, "Pendle". Coney Hill: in calciferous grit.

Scales. Bucks: Bishopstone, Ford, Horton's Pit, in oolitic stone: Dr. Lee's pits; in soft bluish slaty stone. Whitchurch in the "Pendle", with worn roundish particles. Quainton: pit top of the hill; in the "Hardstone".

Reptiles. Portions of a spongy bone, probably Saurian. Garsington, Oxf.: in the "Malm".

Plants. A specimen, represented in Pl. XXII. f. 11., the nature of which is still doubtful. It was bought at Quainton, Bucks, and said to be from the stone-pits at the hill-top; but the precise place was unknown. Not siliceous: effervescing with acids; and in this respect different from the Cycadeæ of Portland.

* Besides the shells above enumerated, the following were found in the strata representing the Purbeck series, within the tract now under consideration; viz. *Bivalves*—of two or three species probably new, but too indistinct to be determined,—at Combe Wood, Oxfordshire; Bishopstone, Weedon, Whitchurch and Quainton, Bucks. *Spiral univalves*—at Garsington and Combe Wood, Oxfordshire, (specimens exhibiting beautifully the internal column of the shell); at Great Hazeley, Oxfordshire, with oolitic particles; and on the road from Whitchurch to Winslow, Bucks,—(a new Paludina?)

Impressions of very narrow leaves. Great Hazeley, Oxf.; in fissile clay, representing, probably, the Fuller's earth of the Lower green-sand.

Trees. At Brill, the trunk of a large tree converted into lignite, was found in bluish grey clay. A most remarkable specimen, 40 feet long; at first entire, with numerous branches; but when I saw it, split into small fragments from decomposition of the pyrites.

Wood. Coniferous, silicified wood, precisely like that of Portland, is found in fragments, in the "Malm", at Garsington, above the Portland stone, and along with portions of freshwater limestone.

[*Portland Stone.*]

Ammonites biplex. Road near Walton turnpike, Bucks.

A——— giganteus. Oving and Dinton, Bucks: with *Exogyra nana*, in sandy stone.

A———. Langcombe, Oxfordsh. Great Hazeley, Oxf.: in grey concreted sand. The Warren, near Stewkley, Bucks: in limestone.

Arca (new). Stone-pits west of Great Milton: a cast in oolitic stone.

Astarte cuneata. Beneath Garsington, Oxf.: in concretional stone. Brill, Bucks: in hard compact limestone.

Buccinum naticoïde. Pl. XXIII. f. 4. Whitchurch, Bucks. The Warren near Stewkley?.

B———. Quainton.

Cardium dissimile. Quainton, Bucks. Brill. Long Crendon: a cast, in grey, very sandy stone. Bishopstone, Moreton's pit: a cast. Tring, road near Walton Turnpike. The Warren near Stewkley.

Cytherea? rugosa. Pl. XXII. fig. 13. Southwarpe, Bucks.

Exogyra nana. Dinton; Bucks: with *Ammonites giganteus*: in sandy stone.

E———. Whitchurch: adhering to *Pecten lamellosus.*

Gastrochæna?. Denton, Oxf.: perforating *Perna quadrata.* Garsington: with *Pecten lamellosus?*.

Gervillia aviculoides. Langcombe, near Oxford: in calcareous spar.

Gryphæa dilatata. Langcombe. A young shell; in Portland stone?.

Lucina Portlandica. Pl. XXII. fig. 12. Southwarpe, Bucks.

Modiola (large). Denton, Oxf. Whitchurch, Bucks: in white stone.

Mytilus. Whitchurch.

Natica elegans. Pl. XXIII. f. 3. Great Hazeley; a cast.

Ostrea expansa. Bucks: Village of Stone; Whitchurch, with *Pecten lamellosus*; Quainton; Brill; Horton's pit, near Ford; the Warren near Stewkley, Bedf.

O——. Remains of a thick-shelled species are found at Great Hazeley, Oxf.: in concretions of gritty stone, in yellowish sand. Haddenham, Bucks. Dinton, with Plicatula.

Panopæa depressa. Brill.

P——— gibbosa. Brill: a cast.

Pecten lamellosus. Oxfordshire: Denton, with *Trigonia gibbosa*; Garsington, with Gastrochæna. Bucks: near Towersey Windmill; Brill, with Exogyra, adhering; Quainton, pit east of Ordnance Station,—in soft limestone; Whitchurch, with Serpula, &c., in white stone; The Warren near Stewkley.

P—— orbicularis. Oxf.: Beneath Garsington; in concretional Portland stone, with *Astarte cuneata*; Langcombe, with *Trigonia clavellata*, in sandy stone. Brill, Bucks.

Perna quadrata. Oxf.: Garsington?; Denton, with Modiola, &c.; Great Hazeley, in gritty stone. Bucks: Towersey, in bluish limestone, with pyrites; Long Crendon, in very sandy stone; Brill; Quainton, "West pit."

Plagiostoma rusticum. Great Hazeley, Oxf.; in calciferous gritty stone.

Pleurotomaria: with large whorls, roundish and flattened. Casts occur at Brill, and at Garsington.

P————. A more acute and larger species, Great Hazeley, Oxf., in calciferous sandstone. Brill; and at the Warren, near Stewkley, Bucks.

Plicatula. Dinton, Bucks: a cast, same as in the "Roche" of Portland.

Pullastra. Remains of shells, perhaps referable to this genus, have been found at Cuddesden, Oxf., in sandy Portland stone; and at the Warren, near Stewkley, Bucks.

Serpula. Remains of. Oxf.: Langcombe; Great Hazeley, in very sandy stone. Bucks: Whitchurch; in white stone; Haddenham, in calciferous sand; Towersey, some specimens of great beauty; Coney Hill.

Siphonia?, casts of Stems: Quainton; Bucks: in soft calcareous sandstone, "Bottom Rock".

Terebra Portlandica. Pl. XXIII. fig. 6. Abundant everywhere in the Portland stone of Oxfordshire and Bucks: at Combe Wood, Oxf.; Southwarpe, Whitchurch, Towersey, &c., Bucks.

Trigonia clavellata. Langcombe, Oxf.: in sandy stone; with a Pecten.

T——— gibbosa. Universal and abundant in the Portland stone. Oxfordshire: Denton, Great Milton, and Combe Wood, immediately in apposition with the "Malm." Bucks: Brill; Long Crendon; Whitchurch; Quainton; Bishopstone.

T——— incurva. Quainton, Bucks.

Venus?. Beneath Garsington: in concretional Portland stone; with *Pecten orbicularis*, and *Astarte cuneata?*. Quainton, pit east of Ordnance Station: in soft limestone*.

Fishes, *Vertebræ of.* Coney Hill: in "sandstone" calciferous grit.

Chimæra Townsendii: (Buckland, Proceedings of Geol. Soc. vol. ii. p. 286.; and Lond. and Edinb. Phil. Mag. 1836. (vol. viii.) p. 4—7.) The beak has been found in the Portland stone at Great Milton, Oxfordshire, by the Rev. C. Townsend.

* Besides the foregoing, fragments of bivalves, too indistinct to be determined, were found in the Portland stone, at Great Hazeley in Oxfordshire; and at Haddenham, Southwarpe, Stone, and Quainton, Bucks.

Reptiles. *Bone of a Saurian.* Great Hazeley: in ferruginous stone.

[*Portland Sand.*]

Ammonites biplex. Oxf.: Dropshot, near Thame, in grey sandy limestone, with numerous green particles, and small pebbles of quartz. Bucks: Dunton, in greenish stone, with dark particles; Quainton, with a Trigonia.

A——— giganteus. Oxf.: Dropshot, (very large specimens): in dark grey limestone, with green particles and pebbles of black chert*; Shotover; in grit. Bucks: Brill; Whitchurch; Dunton; in greenish grey stone, with dark particles. Quainton.

A——— ———? Dunton, Bucks: in greenish grey stone, with dark particles.

Avicula. Oxf.: Shotover, with Serpula and a Pullastra? in sparry grit. Bucks: Whitchurch; large, a cast.

Buccinum naticoïde. Pl. XXIII. f. 4. Brill: a cast.

Cardium dissimile. Oxf.: Langcombe; Dropshot, casts, in matter almost wholly green. Bucks: Hartwell Lodge, with *Trigonia gibbosa*, in bluish grey stone; Dunton; Brill, with Serpula; Whitchurch; Muswell Hill; Quainton.

Cytheræa? rugosa. Pl. XXII. f. 13. Hartwell, Bucks.

Gastrochæna. The Warren, near Stewkley, Bucks: and Shotover Hill, Oxf.: in *Perna quadrata.*

Lucina. Village of Stone, Bucks.

Mytilus (probably a new species). Denton Village, Oxf.: with *Trigonia clavellata.* Brill, Bucks.

Ostrea solitaria. Dunton, Bucks.

O——. Species indistinct. Shotover, Oxf., with Serpula, &c. adhering to *Ammonites giganteus*, and bent into its inequalities. Brill, Bucks.

Panopæa?. Whitchurch, Bucks.

Pecten lamellosus. Dunton, Bucks: in greenish grey stone, with dark particles: and in a mass almost entirely composed of green matter (silicate of iron), with *Perna quadrata.* Muswell Hill; Brill?.

P——. Another species?. Shotover: with Serpula, &c.

Perna quadrata. Oxf.: Dropshot, near Thame, in dark grey limestone, with numerous green particles and pebbles of black chert; Shotover, in sparry grit, perforated by Gastrochæna; with a Venus. Bucks: Muswell Hill, in stone; containing green particles; the Warren; with Gastrochæna, in grey stone; Dunton; in a green friable mass, and in greenish stone, including fragments of black flint, with *Pecten lamellosus.*

Plagiostoma obliquatum. Near Thame, Oxfordshire.

P——— rusticum. The Warren near Stewkley: in bluish grey stone, with minute dark particles.

* At the quarries in the Portland-sand at Barley Hill near Thame, imperfect worn casts of several bivalves, in black flint or chert, are found in the sandy stone, along with pebbles of the same substance.

Serpula. Shotover, with Ostrea; Brill; Coney Hill; Dunton, in green matter.

Trigonia clavellata. Long Crendon; Casts in conglomerate, with siliceous pebbles; and in sandy limestone, with numerous green particles. Dunton, Bucks; with Mytilus.

T——— gibbosa. Denton, Oxf. Hartwell, Bucks; with Cardium, in bluish grey stone. Dunton, and Whitchurch, Bucks.

T——— gibbosa: a variety, less oblique. Brill.

T——— incurva. Brill, Bucks.

Venus. Shotover Hill, Oxf.; with *Perna quadrata.* Hartwell, Bucks; with Trigonia, in soft stone.

[*Kimmeridge Clay.*]

Ammonites biplex. Clay-pits near Aylesbury. Road from Aylesbury to Whitchurch.

A——— biplex (small). East Claydon, Bucks; 20 feet from surface, in clay:

A——— giganteus ?. Clay pits south-west of Stewkley, Bucks: in blue clay.

A——— Gulielmi. East Claydon, Bucks: in clay; beautifully iridescent.

A——— like Gulielmi. Quainton, Bucks.

A——— Selliguinus. Clophill, Bedf. Mr. Goodhall.

A——— (probably new). Clay-pits, south-west of Stewkley, Bucks, in blue clay.

Aptychus (Von Meyer). Pl. XXIII. fig. 11. Roadside between Aylesbury and Whitchurch, about a furlong from Hardwick. Clay pits south-west of Stewkley; fragments of very large specimen.

A——— (a smaller species ?). Roadside between Aylesbury and Whitchurch.

Exogyra nana. Between Aylesbury and Whitchurch: with *Ostrea lævigata.*

E——— virgula. Pl. XXIII. f. 10. (*Gryphæa virgula* of Deshayes.) Roadside between Aylesbury and Whitchurch. Clay-pits south-west of Stewkley: good specimens in bluish grey clay.

Gryphæa bullata. Clophill, Bedf., Mr. Goodhall.

G——— dilatata. Wolvercot, Bucks ?. Clophill, Bedf.

G——— virgula. See *Exogyra.*

Mytilus. Quainton.

Ostrea deltoidea. Aylesbury Clay-pits: a distorted form of the shell. Little Brickhill, clay immediately below surface: fine specimens.

O—— lævigata. Between Aylesbury and Whitchurch.

O—————— (young). Thornborough, Oxf.

O—— læviuscula (young). Road from Aylesbury to Whitchurch: in blue clay. Little Brick Hill, Bedf.

O—— near to *deltoidæa*, but wider at the hinge; still very thick. "In a bed of stiff "clay, about two miles north-north-west of Leighton, under the red sand of the "heath, and about 20 feet above the river." Mr. W. Mathews of Leighton: Roadside between Aylesbury and Whitchurch; Bucks.

Panopæa depressa. Headington Quarry, Oxf.

Pecten arcuatus. Vicinity of Aylesbury.

P—— Lens. Little Brickhill. Brow of the hill, in clay immediately below sand.

Pleurotomaria reticulata (*Trochus*, M.C.) Headington; Oxf.
Serpula tetragona. Clophill, Bedf., Mr. Goodhall.
S —— tricarinata?. Roadside between Aylesbury and Whitchurch. "In stiff clay, "about two miles N.N. west of Leighton." Mr. W. Mathews.

Fishes. *Chimæra* Egertoni: (Buckland, Proc. of Geol. Soc. vol. ii. p. 206.; and Lond. and Edinb. Phil. Mag. (1836), vol. viii. p. 4—7.) Shotover-hill, Oxf.
Psammodus reticulatus: (Agassiz; in Egerton's Catalogue of Fossils); Shotover-hill, Oxfordshire.

Reptiles. *Bone of a Saurian.* Clay-pits south-west of Stewkley: part of a flat bone.
Plesiosaurus; Vertebræ. Headington Quarry, Oxf.
Coprolite; or coproid masses of phosphate of lime. Beneath Whitchurch. Clay-pits south-west of Stewkley: one specimen occupying the cavity of an Ammonite.

[*Oxford Oolite.*]

Melania Heddingtonensis. Wheatley, Oxf.: cast of part of interior.
Ostrea? Thornborough, Oxf. Wheatley; in compact, blue, sparry oolite.
Pholadomya deltoidea. Headington (Coral rag).
Spongia?. Wheatley, Oxf.: in sandy stone.
Terebratula tetrahedra? Thornborough, Oxf.; and Wheatley.

*Cambridgeshire**.

(156.) In this county, as in Bedfordshire, the Wealden and Portland groups are wanting; and the strata, rising with a very slight inclination from the south of east, and thinning off near their outcrop, are frequently cut through by denudation, so that distant outliers, especially of the lower green-sand, are frequent. Mr. M'Lauchlan, who was engaged in the Ordnance Survey of this part of England, remarks, that the summits of the chalk decline rapidly in

* I am indebted to my friend Professor Sedgwick for the greater part of the following information respecting Cambridgeshire. The only publications connected with the geology of the county, are a paper by Professor Hailstone, Geological Transactions, 1st Series, vol. iii. p. 243, &c.; a short paper on the Northern division of Cambridgeshire, by Mr. Lunn, (1818),—Geol. Trans., 1st Series, vol. v. p. 114, &c.; an account of some verbal communications made to the Cambridge Philosophical Society, London Philosophical Magazine, (1835,) vol. vi. p. 74; and the report of a field Lecture by Professor Sedgwick, which appeared in the Cambridge Chronicle of the 10th of April 1835.

Huntingdonshire I have passed over, not having myself examined that county; and I am not acquainted with any publication specifically relating to it, except Mr. Smith's county map. A small space at the south-eastern verge of the county, on the confines of Bedfordshire, is occupied by the Lower green-sand; but all the tract adjoining Cambridgeshire is assigned by Smith to the *Oak-tree clay*, a term which I believe denotes, in this case, the Kimmeridge clay. The strata thereabouts are much obscured by transported matter.

height on the north-east of Bedfordshire: Kensworth Hill, south of Dunstable, being 904 feet above the sea at low water; the hills east of that town 850 feet; Lilleyhoe, 664; Barkway, Windmill-hill, 513; the station near Royston, 484 feet; Balsham, on the east of Cambridge, 380; Newmarket station, 267; Brandon in Suffolk, 190 feet. The summits of the lower chalk successively decline in the same direction; Orwell station being 250 feet, Chapel-Bush, near Haslingfield, 220; Swaffham-Prior (near Reach), 140. And the lower green-sand also falls rapidly: the hills near the outcrop at Bow Brick-hill being 683 feet high; that of Haddenham on the north of Cambridge, 133 feet; and the general surface of the lower green-sand, which tops the hills near that place, ranging from about 60 to 120 feet; at Ely 75 feet. The level of the Cam, upon the gault, at Cambridge, is only $24\frac{1}{2}$ feet above the sea at low water on Lynn Deeps; that of the Kimmeridge clay at Ely Bridge, 14 feet; and of the Cam, at Upware, probably not more than 12 feet. So that if the sea were not dammed out by artificial means, a great part of the marshy tract on the confines of this county, Huntingdonshire, and Norfolk, would be inundated at high water, as appears to have been the case at no very distant period. The hydrography and drainage of this low tract, which are intimately connected with geological principles, have been the subject of some valuable publications, but do not fall within the immediate scope of these pages.

(157.) Another general circumstance which characterizes the north-west of Cambridgeshire, is the great extent and varied composition of the transported masses with which the strata are in many instances thickly invested. This superficial deposit includes worn masses of greenstone, with fragments of many of the lower members of the English series,—and rounded pebbles of chalk, in such abundance as to form a very large proportion of the entire mass. With these stony substances are fragments of the fossils of most of the strata, Belemnites, large Gryphites, the Ostrea (or Gryphite) of the Oxford clay, and portions of the skeletons of Elephants, Rhinoceros, Hippopotamus, Deer of several species, gigantic Oxen, and of the Horse.

The mass thus composed forms many of the hills on the borders of Cambridgeshire and Essex, and occupies a great part of the platform which runs along the confines of the former county and Huntingdonshire; a brown variety of it obscures the junction of the gault and lower green-sand on the west of Cambridge, forming an upland which extends from Bourne by Toft and Hardwick to Dry Drayton, where it declines into the plain*.

* Mr. Hailstone mentions particularly, that the deposits just described are perfectly distinct from that which occurs above the Gault in Cambridgeshire. The former are very well known

These accumulations, it will be perceived, closely resemble those already mentioned in the account of Buckinghamshire and Bedfordshire, especially near Leighton, and at Stewkley. They occupy, in fact, a great extent of the surface, and form one of the most interesting geological deposits throughout the East of England; but there are circumstances respecting their relations to each other, and to the crag of Norfolk and Suffolk, which still remain to be investigated and explained.

(158.) The strata therefore which are found below the chalk in Cambridgeshire, consist of Chalk, Upper green-sand, Gault, Lower green-sand, Kimmeridge clay, Oxford oolite, and Oxford clay; the last occurring only in a few places, and in the remote part of the county, in which it is the lowest member of the series. The sections, Plate X. a, Nos. 22, 23, and 24, explain the general relations of these strata, but have no pretensions to accuracy of local detail. The following notes describe some of the principal appearances connected with the object of this paper; and the publication of the Ordnance maps of the county will no doubt soon lead to the complete examination of it by the geologists of Cambridge.

Chalk.—The upper chalk range passes from the heights near Dunstable, through the north-west of Hertfordshire, by Hitchin and Baldock, to Barkway and Royston Downs, and thence by Balsham and Newmarket into Suffolk. Mr. M'Lauchlan informs me that the chalk ridge at Thorfield (about 570 feet high) is an anticlinal line, and that the overflow of water in Wardington Bottom, near Newsell's-bury Park, while the rest of the country is dry, renders it probable that some of the lower beds are there brought up to the surface. On the Ordnance maps two ridges are distinctly marked, which meet thereabouts at an angle; one passing from Berry Barn through Norfield to Barkway Mill (313 feet high), the other, striking off from Thorfield for about a mile towards the north, turns suddenly to the east, to the group of hills above Royston and Burley, and is continued thence to the north-east through Chishill, 470, and Heydon, 480 feet. The lower tract, in the angle between these ridges, from Newsell's to Known's Folly, may possibly be a valley of elevation like those of Kingclere described by Dr. Buckland.

The outcrop of the lower chalk and chalk marl, is nearly parallel to the range of the upper strata, and to that of the heights above mentioned; its general course being from the neighbourhood of Orwell, through Haslingfield, Cherry Hinton, and Bottisham, to Reach on the margin of the Fens. Thence, from about Milden-hall in Suffolk, near the confines of Cambridgeshire, to Hunstanton, on the north-west coast of Norfolk, a distance of about forty miles, the direction of the chalk escarpment is nearly from south to north.

The chalk which forms the principal part of the lower hills in Cambridgeshire, bears the local name of "Clunch." It is described by Mr. Hailstone as being harder than common chalk, and usually of a grey colour. It affords, as the lower and marly chalk is found to do in many other places, remarkably good lime: and it would seem that some of the lowest beds, which bear the name of Clunch, agree in their properties, as in geological position, with the firestone of Surrey,

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throughout the Isle of Ely under the name of *White Gravel*, (the latter is *Red*); and, Mr. Sedgwick states, are older than the beds of flint gravel in Cambridgeshire.

being applied to the same purposes in the construction of fire-places, &c. Very large pits of clunch have been opened at Reach, on the immediate confines of the Fens, and on the line of Section No. 23.

Upper greensand. This formation here differs from that of some of the more southern counties, in its much smaller thickness, in the absence of chert, and the comparative rarity of green particles, which are here confined to a stratum not more than eighteen inches thick, by which the lowest beds of the chalk are separated from the gault, as is well seen in the section exposed at the Castle Hill, Cambridge. The presence of this green bed, however, is remarkably constant; and it contains many fossils, some of which are common to this formation, and to the chalk,—but others, at least in this country, are confined to the sand; among which, Mr. Sedgwick informs me, Hippurites are found near Bottisham.

Gault.—The term Gault, or "Galt," adopted by Mr. Smith as the denomination of this remarkable stratum, is in Cambridgeshire the popular name for the blue clay, which comes in between the green bed last mentioned, and the ferruginous (Lower green) sand. Its thickness and relations have been well ascertained in this county, from the numerous borings to obtain water, which pierce through the clay to the sand below, especially on the line from Basingbourne north-west of Royston, through Meldrith, and thence towards Cambridge. Its average thickness is about 150 feet*, which is nearly the same as on the south-eastern coast: but the surface of this stratum is much obscured by superficial gravel and a thin coating of the lowest chalk; and good specimens of its fossils are rare, as the upper beds contain but few. Among those, however, which I found between Cambridge and Ely, are the characteristic Ammonites of different species, *A. inflatus*, *A. lautus*, *A. varicosus*; *Exogyra conica*; and spines of an Echinus. In the museum of the Geological Society is a specimen from the Gault near Cambridge, which M. Agassiz has found to belong to a new species of Chimæra†.

Lower green-sand.—This stratum occurs throughout this county between the Gault and Kimmeridge clay, in the form of sand of different shades of grey and brown, but chiefly as a coarse ferruginous compound of quartzose sand, cemented by hydrate and oxide of iron, and more or less indurated. At the top, however, is some green-sand, as appears from the first discharge from the borings through the Gault, after the rod has passed the clay; the water subsequently obtained depositing an ochreous matter, of the colour of the Woburn sands. I have no fossils from this stratum in Cambridgeshire. Its thickness is obviously much less than in Bedfordshire; and its internal composition was not discernible in any of the sections which I saw; but at Ely I found numerous concretional blocks, precisely resembling Kentish rag; which had been obtained, I was informed, from a place near the gallows on the south-west of the town, in a deposit which there forms an extensive outlier over the Kimmeridge clay, and consists of coarse, ferruginous, and siliceous sand and conglomerate, containing a large proportion of brown iron-ore (hydrous oxide of iron), like that of Shanklin in the Isle of Wight. At Ingoldsthorpe in Norfolk, where the thickness of the stratum is probably not greater than at Ely, it is said to contain Fuller's earth‡.

Quitting Potton, in Bedfordshire, Mr. Lunn states§, ferruginous sand is observed within the

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* Mr. Lunn supposes the thickness to be 200 to 220 feet.—Geol. Trans. vol. v. p. 115.

† Proceedings of Geological Society, 1835, vol. ii. p. 205, note.

‡ In Mr. Greenough's geological map, sulphate of barytes is mentioned as occurring on the main road from Royston to Huntingdon, at Longstow near Caxton. This mineral, it will be recollected, occurs in the Fuller's earth at Nutfield in Surrey, ((51.) p. 141.); a situation which answers to that of the Lower green-sand on the line of section No. 22.

§ Geol. Trans. 1st Series, vol. v. p. 114, &c.

borders of Cambridgeshire, at Gamlingay, with Gault resting upon it; "and in some of the pits, "the line of junction is as well defined as that of two immiscible fluids"; but the sand contiguous to the clay is more highly impregnated with iron than the lower part, and is cemented by the oxide, so as to form a hard rock. Leaving to the south-west the two villages of Hatley, both on the Gault, the boundary passes between Little and Great Gransdon, and west of Caxton, (which is on the clay), through the north-west sides of the parish of Eltsley, by Passworth St. Everard's, and Passworth St. Agnes, to Hilton and Fenny Drayton. In the parish of Fenny Stanton and that of Croxton, a bed of clay (Gault?) rests on the sand. The sand can be traced across the lower country, in a direction nearly parallel to the chalk, from Caxton (Section No. 22.) by Conington, and Long Stanton, through Cottenham and Denny Abbey, where the surface is occupied by low hillocks of gravel; and on the north of those places it forms the summit of many of the heights of small elevation on the south-eastern verge of the Fens. Thus at Haddenham, the hill, 133 feet high, is capped with sand; and the prolonged height, or ridge thence to Aldreth, called "the Sandy-way," about 122 feet, is likewise composed of it. The junction of the sand and subjacent clay is well seen, Mr. Sedgwick states, at the clay-pit on the east of Ely; and sand is visible in the drains from about the fifth to the ninth milestone, along the road from Littleport towards Downham, cutting across the Fens on the north-east of Ely, in a direction corresponding to the previous course of this formation near Cambridge.

Kimmeridge clay.—This occupies all the lower tract on the north and west of the line of sands above mentioned, as on the course of the Ouse, or Old West river, from Fenny Stanton and Holywell on the west, to its junction with the Cam at Thetford, and thence towards Ely. Sections are of necessity rare; but a very good one, exhibiting the junction of the clay and Lower green-sand, is exposed in the pits east of Ely. On the west and south-west of Ely the clay is capped in many places by sand, in the form of outliers, on the summits of the heights, which here range from about 120 feet to 50 (see the list in the Appendix C.): and the clay is continued uniformly through their bases, to a point north-west of Haddenham, on the road to Chatteris, where it is succeeded by the Oxford oolite.

Oxford oolite.—A remarkable exception to this uniformity of structure occurs at Upware, on the Cam, about three miles north-west of Reach (see the Section, Plate X. a. No. 24.); where the upper strata of the Oxford oolite make their appearance, in a low ridge extending for about three miles north of Upware, in a direction nearly parallel to that of the Cam, which is here not much more than 12 feet above the sea at low water. The stone beds have been opened here in two or three quarries; a very large one being near the river, and on the line of the section 24. The strata are slightly inclined to the west of north, in a direction opposite to that of the beds below the chalk. The stone here laid bare to a depth of about 10 or 12 feet, consists of a loose rubbly limestone, of a cream colour, in some places coarsely oolitic, and containing many of the characteristic fossils, for a collection of which I am obliged to Professor Sedgwick and Mr. M'Lauchlan:— Spines of Cidaris; Corals; an Arca; Fusus, a new species; *Gervillia aviculoides*; Isocardia, an acute species; Modiola; *Ostrea gregarea*; *Pecten viminalis*; Plagiostoma; Plicatula; *Turbo muricatus*, &c.

The coralline beds (the proper "Coral rag" of Smith) do not come up to the surface at this place; but they break out, Mr. Sedgwick informs me, beyond Haddenham, going towards Chatteris; and he suspects that the shelly beds of this formation occur in some other places in the county, between the Kimmeridge and the Oxford clays, from the occurrence of numerous bits of the coral rag and of its fossils in the brown clay, which masks so much of the surface of Huntingdonshire and Cambridgeshire, and in a condition which makes it probable that they had not been drifted far.

Oxford clay.—The Oxford clay succeeds to the coral rag on the north-west of Haddenham, as has been mentioned, and of Ely. It is the lowest stratum in Cambridgeshire, and forms the base of the Great Bedford Level.

(159.) *Chalk in Rutlandshire.*—The rise of the strata last mentioned, combined with the general features and structure of Cambridgeshire, would seem to indicate the final outcrop and disappearance of the upper members of the Series; but from a passage in a paper by Mr. Barker, published in the Philosophical Transactions for 1791*, and quoted by Dr. Buckland†, it appears that chalk has been discovered at Ridlington in Rutlandshire, about forty miles from the general range of the chalk hills in Cambridgeshire and Norfolk‡. So that if this statement be correct, we might expect to find some of the beds below the chalk, in the wide tract of intervening country. The only circumstance mentioned by Mr. Barker which throws doubt upon the supposition that this chalk is in its original position, is, that the *flints*, which he states to occur "in rows, lying in it as is usual in the South of England," are "broken, and not whole ones." So that it is possible that the entire mass may consist of transported fragments of chalk, and be analogous, but on a much larger scale, to the loose pieces of that substance found by Mr. Conybeare in my presence during an excursion in Northamptonshire, near Sywell; a place about thirty miles distant from the nearest point of the chalk escarpment. Ridlington, where this patch of chalk is stated to have been observed, is placed in Smith's map of the county, on the verge of a platform of the Lower oolite, resting immediately on the blue marl at the upper part of the lias; and the map bears no indication whatsoever of any other stratum.

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* Vol. lxxxi. p. 281. † Geological Transactions, 1st Series, vol. v. p. 539.

‡ I shall here insert the whole passage, as the best mode of presenting the facts to the reader. Mr. Barker, writing at Lynden, near Uppingham in Rutlandshire, says: "I did not know till lately "that we had any chalk nearer us than Moddingley"—(see Pl. X. a. No. 22.); "but several years "ago the people of Riddlington in Rutland, digging for stone to mend the roads, met with a bed of "chalk, at which they were much surprised, and did not know what it was, never having seen a "chalk-pit before. After I had heard of it, I went to examine the place, and found a regular chalk "pit, with rows of flints lying in it as they are wont to do in England. The chalk is not soft, like "that they write with, but very much like that they dig about Baldock: nor are the flints so black "as those in the South of England, but veined, of a light-coloured flint, and white; some parts "much mixed with chalk, and are broken, not whole ones. They may have dug the pit six yards "long and two deep, but how far the chalk reaches I do not know." Mr. Barker adds, that he had seen a little patch of chalk a few yards long, in a bank by the road side, along the turnpike road near Stukely, about three miles north-west of Huntingdon, which place is about twenty miles from the nearest chalk-hills.

Traces of the Wealden in Northamptonshire.—The preceding statement is rendered more interesting by the discovery at Wansford in Northamptonshire, a place about ten miles east of Ridlington, and thirty from the chalk-hills in Cambridgeshire, of a mass of calcareous grit, containing an impression of *Lonchopteris Mantellii**, a fossil species found by Mr. Mantell in the grit of Tilgate Forest, Sussex, and hitherto peculiar to the Wealden strata; indicating therefore the presence of that group at the distance of more than forty miles from the nearest point on the south, at which its existence has yet been ascertained in England. For an opportunity of examining the specimen in question, I am indebted to the kindness of Mr. Woodward of Norwich, to whom it belongs; and I find it to consist of crystalline calciferous grit, of a yellowish grey or drab colour, containing a very large proportion of carbonate of lime,—which may very well have formed a part of one of the concretions of grit subordinate to the Hastings sands. The form of leaf of the plant is beautifully impressed upon the stone, and very well represented in the plate of the Fossil Flora: and the only question is, whether the locality has been correctly stated, which Mr. Woodward has no reason to doubt. It may be added, that the existence of the Wealden in this new situation is rendered more probable by the occurrence of chalk in Rutlandshire, at a point not less remote from the great body of that formation in the South-east of England.

Norfolk†.

(160.) The strata below the chalk appear only on the west of this county, and the series is generally the same with that of Cambridge; but the Upper green-sand soon ceases to be conspicuous, or disappears altogether; and the Gault is so much reduced in thickness, and changes its character so remarkably, that it is only by means of its fossils and by tracing its continuity with the more usual form of the stratum, that its identity can be ascertained. The ferruginous beds of the Lower green-sand are sufficiently distinct, but the formation is much thinner than in the south-eastern counties. No traces of the Wealden or Portland groups have yet been found, nor are there any

* Lindley and Hutton's *Fossil Flora*, (1835) vol. iii. p. 372. Plate 171.

† The publications on the geology of Norfolk, besides the general maps of Smith and Greenough, and the County map of the former, relate principally to the eastern portion of the county. But since these pages have been at the press, an excellent account of West Norfolk, by Mr. R. C. Rose, of Swaffham, has appeared in the London and Edinburgh Philosophical Magazine[1], to which I beg to refer the reader who wishes for detail. The preceding papers relating to this part of the county, are Mr. R. C. Taylor's plate and description of Hunstanton Cliff, 1823[2]; a paper by the same author, on the alluvial strata and the chalk of Norfolk and Suffolk[3]; and a list of the fossils of Hunstanton, in Mr. Woodward's Geology of Norfolk[4]. Some occasional notes connected with the west side of the county, may also be found in the tracts more immediately relating to the beds above the chalk.

[1] Vol. vi. and vii. 1835—1836.

[2] Phil. Magazine, 1823, vol. lxi. p. 81—83; republished in a tract on the Geology of East Norfolk, 8vo, 1827.

[3] Geol. Trans. 2nd Series, vol. i. p. 374—378.

[4] "An Outline of the Geology of Norfolk," 8vo, 1833.

distinct indications of the Oxford oolite, between the Kimmeridge and Oxford clays.

The line of hills, nowhere probably exceeding 600 feet in height, which stretches for about forty miles from the chalk range of Cambridgeshire to the north-west coast of Norfolk, bounds the fen-country like the low shore of a sea; and a very slight change of level would again convert the fens into a shallow estuary, by the waters of which these hills would be washed at their base. At present, the face of the heights is covered with vegetation, so that it is only in detached spots casually exposed, that the strata can be seen.

Not having, myself, any good section of this part of the district, Mr. Rose has been so good, at my request, as to prepare an enlarged copy of the sketch annexed to his paper on West Norfolk, on the line from Swaffham to Lynn, (see Pl. X. a, No. 25.); and I have inserted also a section and a sketch of Hunstanton Cliff, (Plate X. a, No. 26; and X. b, fig. 12, *a*, *b*, and *c*,) the only natural section that is visible upon the coast.

Deposits above the Chalk.—The portion of the fens immediately adjacent to the chalk-hills in West Norfolk, bears the name of Marshland. It is composed of alternating beds of lacustrine silt and peat, covering, in the vicinity of Lynn, a deposit of marine silt; the whole resting upon a stiff clay, which incloses small nodules of chalk, and is obviously the same with the superficial deposit, already described as including chalk fragments and being generally of similar composition, in Cambridgeshire and near Leighton; beneath which are the strata of Kimmeridge in Oxford clay.

In a well, sunk and bored at Lynn, to the great depth of 630 feet, the detail of which will be mentioned hereafter, a bed of the clay containing portions of chalk, was found beneath about 23 feet of sand, loam, and peat, and marine silt; and the clay was, at the bottom, in immediate contact with what Mr. Rose considers as the Oxford-clay, but with some doubt whether it may not be that of Kimmeridge. For an account of the newer subaqueous deposits, and of the more recent changes which the surface here is proved, by historical documents, to have undergone, I refer to the publications of Mr. R. Taylor, Mr. Woodward, and Mr. Rose, in which references will be found to preceding authors, some of whom are of very ancient date.

Chalk.—An account is given in the publications of this Society, of two borings in the south of Norfolk, which illustrate the relations of the chalk to the beds immediately beneath it. One of these, described by Sir H. Bunbury, was made at Mildenhall in Suffolk*, a spot about twenty miles north-east of Cambridge, and thirteen from Ely, near the point where the chalk range changes its direction from about south-west and north-east, and runs northward, to join the sea at Hunstanton†. Another sectional list has been published by Mr. John Taylor, derived from a boring at

* Geol. Trans. 2nd Series, vol. i. p. 379.

† The general course of the chalk escarpment in the Wolds of Lincolnshire (see a paper by Mr. Bogg, Geol. Trans. 1st Series, vol. iii. p. 392.) and of Yorkshire, is from south-east to north-west; so that the line of its course in Norfolk may be considered as forming the bottom or most eastern shore of a deep bay, (and the lowest part also of the range, with reference to the level of the sea); from the extremities of which the escarpment diverges in both directions;—north-westward, for about ninety miles, to its final termination on the parallel of Flamborough Head; and towards the south-west, for more than two hundred miles, to the coast of Devonshire.

Diss, on the confines of Norfolk and Suffolk*, about five-and-twenty miles east of Mildenhall; through which place if a line were drawn on the line of dip, it would pass nearly through Downham on the margin of the Fens. In this section, the entire thickness of the chalk was cut through, and combining it with that at Mildenhall, the result stands thus;—subject, however, to some uncertainty, from the imperfect condition of the specimens brought up in boring.

Diss.		Feet.
1. *a.* Clay	50	
b. Sand	50	100
2. *Chalk.*		
a. Without flints, soft, marly	100	
b. With flints, in layers about a yard from each other	330	
c. Grey, with occasional layers of white: no flints	60	
d. Light bright blue chalk, approaching to clay, with white chalk stones	20	510
[On penetrating the light blue clay, the boring-rods sank rapidly, and water rose to within 47 feet of the surface.]		
3. *Sand*;—characters not stated	5	5
		615

Mildenhall.		Feet.
I. Sandy loam		1
II. *Chalk.*		
a. White, without flints	35	
b. Yellowish, gritty	5	
c. Grey, hard	136	176
III. *a.* Blue clay	54	
b. Ditto, darker and harder	10	
c. Ditto, mixed with green sand	10	74
		250
IV. *Green sand*, with many fossils		11
V. *Blue clay*, abounding in fragments of large shells, having a high polish		9
[Water coming in here, the work was discontinued.]		270

The section at Diss is valuable, as it cuts through the entire thickness of the chalk, which is here 510 feet; of which, it will be remarked, the uppermost 100 feet are marly and without flints. The light blue stratum, 2. *d*, referred by Mr. Rose to the Gault, may, perhaps, rather correspond to the lower portion of the chalk-marl, and to part of III. in the Mildenhall section; in which case 3. at Diss would represent the Upper green-sand. V. at Mildenhall is distinctly referred by Sir H. Bunbury to the *Gault*, which he supposes to occupy the flat surface of the adjacent fen.

Mr. Rose states that the chalk range in West Norfolk dips to the south-east, about five yards in a mile; or about 1 in 350. He has requested me to mention that he considers the estimate of the heights given in his paper as probably exceeding the truth; and at my suggestion, derived from the levels in Cambridgeshire, he has reduced the altitudes in the section, Pl. X. a. No. 25.

The upper chalk of Norfolk includes the usual flint nodules; and among the larger flinty masses are some like those described by Dr. Buckland, under the name of Paramoudra. Many of the fossils of the uppermost strata, according to Mr. Woodward, are different from those of what he has called the *medial chalk*, which also contains flints. Near Swaffham, the chalk without flints, which seems to belong to some intermediate beds between the upper and lower

* Proceedings of the Geol. Soc. (1833-4), vol. ii. p. 93.

groups, forms a range of somewhat lower hills, on the west of that constituted by the superior strata. It is hard enough to be used as a building stone, divides naturally into rhomboids, and contains horizontal seams of argillaceous matter; but Mr. Rose remarks, that although the hardness increases progressively downwards, the increase is not regular nor uniform, some portions as hard as any of the lower occurring in the upper part of it. His list of fossils from the chalk with flints contains about 78 species; of which, according to Mr. Mantell, only 40 occur in the corresponding part of the formation in Sussex.

The relations of the lower strata of the chalk are best exhibited in the section at Hunstanton Cliff, which will be presently described. Mr. Rose's list of fossils from the chalk without flints, includes altogether 54 species; of which 30 are found in the upper part of Hunstanton Cliff:—of the whole number only 15 species are wanting in Mr. Mantell's catalogue of the Sussex chalk fossils*.

Upper green-sand.—It is probable that attentive examination would discover the usual green matter on the confines of the chalk and the representative of the gault in this county: but generally the Upper green-sand is scarcely perceptible. In the section at Mildenhall, inserted above, 10 feet of clay mixed with green particles, precede 11 feet of (upper) green-sand with many fossils, which rests on blue clay, no doubt the Gault: and the five feet of sand which occur at the bottom of the boring at Diss may also (possibly) belong to the former. Mr. Murchison considers one of the beds at Hunstanton, as the representative of the malm rock of Western Sussex; and Mr. Rose also mentions a rock like firestone, on the confines of the chalk, a resemblance which I find is indicated in my own notes.

Gault.—This stratum is very distinct at Mildenhall, below green-sand; and is represented in Smith's map, as occurring all along the line of escarpment, between the lower chalk and the lower ferruginous sand. I have myself seen it with the characteristic fossils at East Winch and several other places. Thus at Mosshill Farm ("*Muzzle*" of the Ordnance Map), west of the house, towards Denver, are several pits, in a patch, or cap of bluish clay, over the Lower green-sand: the former including Belemnites in great numbers, phosphate of lime in kidney-shaped (coproid) concretions, a few specimens of Ammonites, and fragments of Inocerami in great numbers. On the heights between Middleton Tower and Devil's Bottom, north of the section, Pl. X. a. No. 25, are patches of white and yellowish grey clay, containing many of the Gault fossils;—Belemnites, Inocerami in fragments, Echinus-spines, and portions of Encrinites. In fact, most of the heights in this part of the country, are thinly covered with gault; while the sand beneath it rises slowly towards the west.

The average thickness of the Gault in West Norfolk is not more than 15 feet, according to Mr. Rose, who has traced the connexion between the detached portions, indicated in Smith's map, as far as West Newton, about three miles south of Ingoldsthorpe. The valley between the chalk and Lower green-sand is there interrupted by an advance of the chalk, and beyond that point the *blue* Gault is no longer observable; its place being occupied by the red marly stratum of Hunstanton Cliff. The position of this red matter falls in with the strike of the blue Gault in the southern part of the range, at Newton; and it has been detected, between that place and Hunstanton, at Dersingham Mill, and at Ingoldsthorpe, where I myself have seen that the red stratum is immediately succeeded by sand, the blue beds being wanting.

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* Geol. Trans. 2nd Series, vol. iii. p. 201, &c.; and Geology of the South-east of England, (1833.) p. 370, &c.

Lower green-sand.—This formation here consists, at the upper part, of highly ferruginous coarse sand, one of the most remarkable components of which is Titaniferous oxidulated iron*. The sand abounds in hard concretions of siliceous grains cemented by ferruginous matter, in the form of thin flakes or bands, irregularly ramified, which, in Norfolk, are called "Carstone";—beneath which is finer sand of different shades of grey, yellowish, and white. The course of the outcrop is generally parallel to that of the chalk: the chief localities and the local varieties are indicated in Mr. Rose's memoir.

In descending a hill on the road from Lynn to Snettisham, about a mile from the village of Dersingham, is *white* sand, under yellow slightly consolidated sand; and near the line of the section No. 25, between 38 miles and 39 from Norwich, about half a mile from Middleton, are pits of yellowish and white sand, with ferruginous concretional bands, apparently belonging to the upper member of the Lower green-sand; and very like the Woburn sands.

Organic remains must be very rare in this formation, as Mr. Rose states that he had not obtained any specimens. At Ingoldsthorpe, however, in a brick-field near *Mount Amelia*, I found casts of the following shells, in masses of agglutinated ferruginous sand, like those of Parham-park in Western Sussex, and of the cliff on the west of Shanklin Chine in the Isle of Wight; *Auricula incrassata*; *Avicula*, a new species; *Corbula striatula*; *Mya plicata*; *Rostellaria calcarata*; *Turritella granulata*; *Venus Faba*; and some other indistinct bivalves and univalves.

No indications occur in the sections of this formation which I saw, nor in those mentioned by Mr. Rose, of the threefold subdivision of the Kentish coast; but in the lower part are thin courses of Fuller's earth, not more than an inch in thickness. The lower beds are stated by Mr. Rose generally to contain thin strata of Fuller's earth; as in Surrey and at Woburn.

(161.) *Hunstanton.*—The cliff at this place exhibits an epitome of all the lower strata above described: the section is very distinct, and the difference in the characters and proportion of the beds from those of the southern counties is so remarkable, that I think it necessary to give an account of them, although the place has been already described by Mr. R. C. Taylor† and Mr. Rose.

Pl. X. a. No. 26, represents the cliff, on the same scale with the other sections in that plate, and with Plate X. b. fig. 12. *a*, which is copied from a portion of the Ordnance Map of Norfolk. Fig. 12. *b*. is a sectional elevation, for which I am indebted to Mr. Murchison; and fig. 12. *c*, a sketch of part of the cliff, by Mr. Whewell, with whom and Professor Sedgwick, I had the pleasure of examining the place in 1827.

The following is Mr. Murchison's description of his section, (Pl. X. b. fig. 12. b.), with some additions from my own notes. The dip is, generally, to the north-east; but it will be observed that there is an angle in the coast; so that the section is strictly divisible into two portions, in different planes, neither of them coincident in direction with the line of dip.

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* London and Edinburgh Phil. Mag., 3rd Ser., vol. vii. p. 179.; Phillips's Mineralogy, 3rd edit. p. 223.

† Geology of East Norfolk; and Phil. Mag. 1823, vol. lxi. p. 81.

Section at Hunstanton Cliff.

	Ft.	In.
1. Dunes* of loose blown sand.		
2. Reddish clay, passing downwards into fine laminated sand; with bands of small pebbles ..... 9 0 to	10	0
3. Chalk, increasing as it rises, and attaining its greatest thickness in the cliff under the lighthouse. It is there about 30 feet thick, and divisible into three:—		
a. Grey chalk, in thin beds 20 0		
b. Grey chalk, in beds, from 1 to 3 feet in thickness 3 0		
c. The lower part, for about 8 or 10 feet, includes myriads of Inoceramus, chiefly in fragments, with large Ammonites ..... 6 0 to 8 0		
about	30	0

In my own notes I find it stated, that some of the gritty portions of the beds in this part of the cliff are very like the Surrey *firestone*.

[*Upper green-sand*??]

4. A "hard grey bed" like the malm-rock of Western Sussex (the upper member of the Upper green-sand), including great numbers of ramified stems.—*Quæ.* of Siphonia? ..... 1 6 to	2	0

[*Gault*??]

5. Red calcareous and argillaceous matter; with multitudes of *Belemnites Listeri*, Inoceramus, *Pecten orbicularis*, and some Terebratulæ; generally divisible into two beds. This is essentially a conglomerate, or breccia; being composed of angular fragments of black flint or flinty slate, imbedded in a very large proportion of hard, marly, chalk-like matter, and varying in hue from a full to a pale brick-red. The colour is not improbably caused by oxide of iron derived from the ferruginous sands below	4	0

[*Lower green-sand.*]

6. *a.* Yellow sandstone, rather incoherent, with hollow concretions, and curved bands of bluish oxide of iron (the "*Carstone*" of Norfolk, "*Clinkers*" of Hampshire), with quartz pebbles the size of beans. Some stems of Siphonia in the upper portion ..... 10 0 to	12	0	
b. is composed of siliceous pebbles and broken fragments of flint, united by a very large proportion of dark brown ferruginous matter; which, under the salt water becomes nearly black. The mass is traversed by fissures, which divide it into oblong blocks, and are sometimes occupied by carbonate of lime. Continued downwards: about 14 feet are visible	14	0	
		26	0
Total thickness of the Section†		60	0

On the shore at the west end of the cliff, I observed numerous concretional masses of a green conglomerate; obviously part of a bed, like that of the shore below the cliff at Shanklin, and at Sandown Bay, in the Isle of Wight.

The *Chalk without flints*, which forms the upper part of the cliff at Hunstanton, rises, according to Mr. Rose, about 15 yards in a mile; the general inclination of the strata around Swaffham (Section No. 25.) being about 5 yards in a mile. This part of the chalk at Hunstanton comes down into contact with the *Red* Chalk (the Upper green-sand being wanting), and, according to Mr. Rose, admits of subdivision into three portions. 1. Chalk, of a pure white colour. 2. Grey chalk, of a sandy texture,—(No. 3. of Mr. Muggridge's Section given in the note below). This

* This word is in some parts of Norfolk written "*Denes*." In the village of Hunstanton are loose blocks of green-stone and basaltic porphyry, of considerable size and worn at the edges; and in the transported matter, at the signal end of the cliff, were some pieces of mountain limestone.

† The measurements of Mr. Taylor and of Mr. Muggridge (published by Mr. Rose) coincide

contains very hard masses distributed through softer matter, and is stated by Mr. Woodward, to include a mixture of the fossils of the Upper green-sand with those of the chalk marl. 3. A bed of hard chalk, composed entirely of a ramose zoophyte;—(No. 4. of Mr. Murchison's Section and part of 4. of Mr. Muggridge's mentioned below).

The beds between the white chalk and the Lower green-sand here, differ much from those of the southern counties. The Upper green-sand, if it be present at all, is very indistinct: the green particles which, in other places, abound in this part of the series, are wanting; and the thickness, which in the Isle of Wight is 60 or 70 feet, is here reduced to 2 feet. The Gault has but a doubtful representative; and instead of resembling the blue clay of the South, appears under the form of *reddish* marl, not more than 4 feet thick*.

Mr. Woodward gives a list of 16 species of shells, from this red matter at Hunstanton; of which number only five occur in the Gault of the southern counties: seven are found in the Chalk; four in the Upper green-sand, at some other places; three in the Lower green-sand; and the five following occur only in the red chalk,—*Ammonites alternatus, Spatangus planus, Spongia paradoxa, Terebratula pentangulata, T. triplicata.*—Geology of Norfolk, p. 54.

Kimmeridge clay.—This stratum, in West Norfolk, succeeds immediately to the Lower green-sand, all along the line of escarpment. It can be seen in several detached points, between Southrey, about the tenth mile on the road from Ely to Lynn, and the shore beneath Hunstanton

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very nearly, with those of Mr. Murchison and myself, though their divisions of the strata are not quite the same.

Taylor, 1823.	Ft.	In.	*Muggridge*, 1835.	Ft.	In.	*Murchison*, 1831;—*Fitton*, 1827.	Ft.	In.
1. Soil and diluvium ... 6 in. to	4	0	1. Soil and diluvium.....					
2. Chalk, with few organic remains ... 36	0		2. Lowest chalk..... 28	0				
3. —— Very hard ... 3	0	39 0	3. Chalk marl... 2 6 to 3	0	31 0	No. 3.	20	0
4. —— White, with a ramified zoophyte, like roots of trees	1	6	4. White zoophytic bed...1 4 to		1 6	No. 4. 1 6 to 2	0	
5. Deep red matter; 1 in. to.....	0	6	—— Seam of red argillaceous matter 0 2 to	0	3			
6. Red chalk 2	0		5. Red zoophytic limestone, (representing the gault,) in two beds.....	3	10	No. 5.....	4	0
7. Red chalk; darker and more compact than 6..... 2	0	4 0			4 1			
8. Sand, light brown ferruginous, containing titaniferous iron ore.....	10	0	6. Lower green-sand	8	9	No. 6.		
9. Puddingstone and sandy breccia, very dark brown...	40	0	7. Carstone			*a.* 10 ft. to 12	0	
10. Very dark puddingstone, in some places almost black: discernible only at low water ..... visible about	20	0	8. Sandy breccia 14	0		*b.* 14	0	

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* Similar beds of Red marl occur in the corresponding place beneath the chalk-wolds of Lincolnshire, (see a paper by Mr. Bogg, Geol. Trans. 1st Series, vol. iii. p. 392, &c.); and appear again at Speeton, near Flamborough Head, on the Yorkshire coast;—where, however, they are distinctly superior to the blue gault, and are regarded by Mr. Phillips, as forming part of the chalk.—Geology of Yorkshire, (1st ed.) p. 75; and Section No. 3.

Cliff, where its occurrence is mentioned by Mr. R. C. Taylor; and Mr. Woodward states, that beneath 13 feet of brick-earth, near the former place, a few inches of bituminous shale were found, which burned readily and contained between its laminæ impressions of an Ammonite, and a small bivalve, (Tellina?).*

At Southrey, I found in the clay many of the characteristic Kimmeridge fossils, among which are *Ostrea deltoidea*, *Ammonites Lamberti*, Aptychus, like that of Buckinghamshire (Pl. XXIII. fig. 11.), and a Vermetus; with fragments of the teeth and bones of Saurians.

In a brick-field beneath Downham Market, where 5 or 6 feet of clay were exposed, I found *Ostrea deltoidea*, another large bivalve, and a great number of Ammonites (*A. biplex*?) much compressed. In a section at Denver Sluice, near Downham, the order was as follows†:—

	Ft.	In.
1. Sandy loam, peat and clay; containing roots of plants	23	0
2. Dark ferruginous sand	3	0
3. Clay; which, from its position and contact with sand, seems to be that of Kimmeridge	7	0

The *Oxford oolite* has not been found in this part of the country; nor the subjacent calcareous grit.

The only mode, therefore, in which the presence of the *Oxford clay* can be ascertained, is by its fossils; for, although the great depth of clay passed through at Lynn, in the well sunk and bored at Mr. Allen's brewery, exceeds the average thickness of the Kimmeridge clay, even when combined with the Weymouth strata, identity cannot be safely denied, on the evidence of thickness alone. More than 630 feet of clay were cut through in this well, after passing through between 40 and 50 feet of loam, peat, clay, and marine silt. Of this great thickness a part no doubt belongs to the Kimmeridge clay; and the fossils obtained from the lower beds, now in Mr. Rose's possession, offer no very decisive proof that the Oxford clay is there. But on the other hand, none of the more characteristic fossils of Kimmeridge occur in it, except, *Ostrea deltoidea*;—no *Gryphæa Virgula*, nor Aptychus. The list given by Mr. Rose, includes *Ammonites decipiens*; *A. excavatus*, and another very small species; *Belemnites abbreviatus*; *Gryphæa bullata*, with *Serpula tricarinata* attached to it; *Mya depressa* (a Kimmeridge clay fossil?); a *Pecten* impressed upon a Venus; and a muricated spine of an Echinus. Among the specimens from the deep well which I find mentioned in my notes of 1827, are a *large* Ammonite; two others of small size (one very like *A. Kelloviensis*); *Gryphæa dilatata*, with another bivalve adhering; *Ostrea deltoidea*; two indistinct bivalves; and part of a flat bone.

(162.) *List of Fossils of the Beds below the Chalk, in* Bedfordshire, Cambridgeshire, *and* Norfolk.

Gault:—including the red stratum at Hunstanton.

Ammonites dentatus. Ingoldsthorpe, Norfolk: in grey sandy clay.
A——— *inflatus*, young. Between Cambridge and Ely.
A——— *lautus.* Between Cambridge and Ely: in green sand, at the bottom of the Gault.
A——— *varicosus.* Between Cambridge and Ely?

* Rose, p. 176. † Ibid., p. 173.

Belemnites attenuatus. Ingoldsthorpe, Norfolk.

B——— minimus. Ingoldsthorpe: in very light gray marl, with an Inoceramus. Hunstanton: a very large specimen, in the red marl.

Dentalium, with *Exogyra conica.* Between Cambridge and Ely.

Echinus; spine and fragments. Between Cambridge and Ely: in gray marly clay; Ingoldsthorpe. Hunstanton.

Exogyra conica. Between Cambridge and Ely: with part of a Dentalium.

Gryphæa globosa. Hunstanton: with fragments of Inoceramus, and numerous quartzy particles, in red marl.

Inoceramus concentricus? Hunstanton: in red marl.

I——— Cripsii: (Mantell). Hunstanton: red marl.

I——— intermedius? Hunstanton.

I——— sulcatus. Woburn, Bedfordshire.

I——— (indistinct.) Ingoldsthorpe: in light gray marl; with *Belemnites minimus.* Hunstanton: shell very thick, in red marl; with *Belemnites minimus?*

Pecten Beaveri. Hunstanton: with stems of Siphonia?

Siphonia. Hunstanton: in gray marl; (*Lower chalk?*)

Terebratula biplicata. Hunstanton; in the red marl.

T——— subundata. Hunstanton; in the red marl.

Lower Green-sand.

Auricula incrassata. Brick-field, near Ingoldsthorpe, Norfolk; in ferruginous masses, like those of Parham Park, Sussex,—with the following:—

Avicula (new); *Natica*; *Panopœa plicata*; *Rostellaria calcarata*; *Turritella granulata*; *Venus Faba.*

Kimmeridge Clay.

Ammonites biplex. Asplay, near Woburn: in gravel.

A——— Lamberti. Between Cambridge and Ely: in clay, probably that of Kimmeridge.

Aptychus; Von Meyer:—(Trigonellites of Parkinson.) Pl. XXIII. fig. 11. Roadside between Cambridge and Ely. The same as near Whitchurch and Stewkley, Bucks; supra, pp. 292 and 302.

Ostrea; fragments. Between Cambridge and Ely.

Oxford Oolite.

At Upware, on the banks of the Cam, about eight miles below Cambridge, the following fossils are found, in coarse limestone:—

Arca. Astrea. Cidaris; spine. *Cucullœa*; with Pecten and other fossils. *Fusus. Gastrochæna. Gervillia aviculoides*; with *Turbo muricatus. Isocardia* (new); very acute. *Littorina muricata. Modiola* (indistinct.) *Ostrea gregaria. Pecten vimineus. Plagiostoma cardiiforme. Plicatula. Trigonia Pullus. Turbo* (indistinct). *Turritella muricata? Venus* (cast, imperfect).

SUMMARY AND GENERAL REMARKS.

(163.) The order of the strata mentioned in the preceding pages is represented generally in the abstract Section, Pl. X. b. fig. 13.

Thickness of Strata.—I have not inserted in the engraved section the thickness of the groups; both because it varies much in different places, and that in general my estimates are so loose as not to be relied upon. Accurate measurements of the thickness of the English strata have very seldom been made. The following are approximate numbers, derived however, principally, from estimates by the eye.

Chalk.—The entire thickness of the chalk is exposed in many of the sections on the south-eastern coast; but westward of the Isle of Wight the beds are convergent and much reduced in bulk. Between Deal and Folkstone, Mr. W. Phillips has estimated the total thickness at 820 feet[1]. The two sections at the extremities of the Isle of Wight, between Whitecliff and Sandown Bays on the east,—and between Alum Bay and Broadbench, at the western extremity of the central ridge, furnish good evidence; the strata being so nearly vertical, that the horizontal line across their direction, does not very much exceed the perpendicular to their surfaces. Mr. Greenough has accordingly estimated the thickness at Culver at 1300 feet[2]; and the interval on the Ordnance map, which is very nearly the same at the two extremities of the island, (being in both places about 2 furlongs, or 1320 feet,) may probably be considered as somewhat exceeding the maximum thickness of the chalk in England.

Mr. Conybeare estimates the chalk as ranging between 600 and 1000 feet[3]; and Mr. De la Beche at 700[4]. The height of the cliff at Beachy Head, which includes at top part of the flinty chalk, and goes down very nearly to the Upper green-sand, is only 535 feet[5]; but if 250 feet be added, for the remainder of the flinty chalk, (350 being the thickness of that division near Dover[6],) the aggregate thickness on the Sussex coast will be about 800 feet.

At Wendover Hill, the summit employed as the Ordnance Station is 905 feet above the sea[7]; and the canal at Wendover being 404½ feet, and still within the chalk, the difference, 500 feet, is certainly less than the total thickness at that place.

But the whole of the chalk passed through in the boring above mentioned, at Diss in Norfolk[8], (which includes at the top 100 feet without flints,) was only 510 feet.

The wide range of variation in thickness above stated (supposing the measures to be correct), arises in a great measure from the unequal abrasion and removal of the upper strata; but must in part also be ascribed to original inequality in the thickness of the chalk itself.

Upper green-sand.—The thickness of this group near Folkstone does not exceed 30 feet, and is probably much less[9]; but it swells out considerably near Godstone, and Merstham, and at the latter place is upwards of 30 feet thick[10]. The depth of the wells sunk through it, in the Malm rock strata of Hampshire, varies from 60 to 100 feet[11]. In Western Sussex the thickness

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[1] Geol. Trans., 1st Ser. vol. v. p. 18. [2] Conybeare, Outlines, &c. p. 85.
[3] Ibid. [4] Tabular View, 2nd edit. [5] Section, No. 6. Plate X. a.
[6] Phillips, Geol. Trans., 1st Ser. vol. v. p. 18. [7] Supra (149.), p. 284; and Sect. 20, Pl. X. a.
[8] (160.), p. 311. [9] (9.), p. 107. [10] (49.), p. 140. [11] Murchison, Geol. Trans., 2nd Series, vol. ii. p. 99.

is between 70 and 80 feet[1]; in the Isle of Wight, about 70 feet[2]. At Blackdown the thickness of the sand is about 100 feet[3]; in the Vale of Wardour, probably from 60 to 80[4]; near Swindon, 30 to 50 feet[5]: but at the Castle Hill, Cambridge, it is not more than 18 inches[6]. Thence through West Norfolk, the stratum is not anywhere distinctly seen; and at Hunstanton, the only beds which can be supposed to represent it, are not more than 2 feet thick[7].

Gault.—The thickness of this stratum near Copt Point, derived from barometric measurement, is about 130 feet[8]. In the interior it is difficult to obtain good estimates, and accurate measures can be expected only in wells. At Merstham it is about 150 feet thick[9]; in the Isle of Wight probably about 70 feet[10]: at Ridge, in the Vale of Wardour, it is about 75 feet[11]; at Cotmore Wells near Thame, 90 feet[12]. In Cambridgeshire, the entire stratum has been cut through repeatedly in wells and borings, which give an average thickness of 150 feet[13]; but at Mildenhall in Suffolk, the blue clay, which seems to represent it, is only 9 feet[14]. In West Norfolk Mr. Rose considers that the utmost thickness cannot be more than 15 feet[15]; and at Hunstanton the red marly beds which are supposed to contain Gault fossils, are only 4 feet thick[16].

Lower green-sand.—The measured thickness of this formation can be most easily obtained on the shore between Copt Point and Hythe, where the uppermost subdivision is about 70 feet thick[17]; the middle group, 70 to 100 feet[18]; and the lowest, 60 to 80 feet[19]; the total thickness consequently about 250 feet. In Western Sussex, Mr. Murchison states that nearly 400 feet of sand were passed through in a boring, at Petworth Summerhouse[20]; and Mr. Martin conceives that the two lower members may be together about 150 feet thick[21]. In the Isle of Wight the thickness, between Bonchurch Cove and Sandown, Rocken End and Atherfield Rocks, cannot be less than that of the formation near Folkstone, and seems to be much greater. At Brill, in Buckinghamshire, about 26 feet remain[22]; in West Norfolk, Mr. Rose considers the thickness of the whole formation to be about 80 feet[23].

Wealden.—No measures, on good estimates, of the thickness of the strata in this group have yet been obtained. Mr. Martin assigns 281 feet to the *Weald-clay* cut through in boring, at Petworth in Western Sussex[24]; but in the section at Tiepit and Cowleaze Chine in the Isle of Wight, the clay seems to be no more than 140 feet thick[25].

The section of that part of the *Hastings-sands* which is visible between St. Leonard's Church and the top of the great sand rock bed, may be about 200 to 250 feet; the sand rock bed itself, under the castle, about 80 to 120 feet; and thence to the lowest point upon the coast, east of Hastings, about 200 or 250.—Total thickness, between 400 and 500 feet[26].

It is difficult, from their contortions, to estimate the thickness of the *Purbeck strata* on the coast. Mr. Webster has given in detail the stratification of a portion of them, which amounts to 124 feet, 8 inches[27]; to which may be added about 150 feet,—making a total of about 275[28]. In the Vale of Wardour, the total remaining thickness of the group appears to be from 40 to 60

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[1] Martin, p. 20,—who states, however that 100 feet would probably be no exaggeration of the thickness, where the stratum first emerges from beneath the chalk. [2] Webster, Letters, &c., p. 140.: and supra (93.), p. 183. [3] Supra (120.), p. 236.; and (93.) p. 183. [4] (128.), p. 216.; (129.), p. 247. [5] (141.), p. 265. [6] (158.), p. 305. [7] (161.), p. 314. [8] (11.), p. 109. [9] (49.), p. 140. [10] (93.), p. 184. [11] (129.), p. 247. [12] (148.), p. 279. [13] (158.), p. 306. [14] (160.), p. 311. [15] Rose, p. 181. [16] Supra (161.), p. 314. [17] (17.), p. 116. [18] (25.) p. 122. [19] (32.) p. 126. [20] Geol. Trans., 2nd Ser. vol. ii. p. 102. [21] Martin, p. 36—40. [22] (148.), A. p. 280. [23] Rose, p. 176. [24] Martin, p. 36. and 40. [25] Supra (100.), p. 198. [26] (80.) to (84.), p. 163—172. [27] Geol. Trans., 2nd Ser. vol. ii. p. 39. [28] Supra (104.), p. 209.

feet[1], and in Buckinghamshire still less[2]. Mr. De la Beche estimates the whole formation at 250 feet[3]. The aggregate thickness, therefore, of the three groups which compose the Wealden, cannot, probably, be less than 800 feet.

Portland stone.—This formation being well defined and fully exposed, its thickness is well ascertained; and in Portland Island it seems to range between 60 feet[4] and about 70[5]; at Swindon it is about 60 to 65[6]: at Great Hazeley in Oxfordshire 27 feet[7]; at Brill, about 23 feet[8]; near Quainton and Whitchurch in Buckinghamshire, from 4 to 20 feet[9].

Portland sand.—Near St. Alban's Head, Isle of Purbeck, 120 to 140? feet[10]; in the Isle of Portland, 80 feet[11]; near Thame in Oxfordshire, about 50 feet[12].

Kimmeridge clay.—The thickness of this group is uncertain, and seems to vary much in different places. On the coast Messrs. Buckland and De la Beche assign to it 600 feet, at Kimmeridge Bay[13]; but they state the thickness at Ringstead Bay to be only 300 feet[14]. At the Headington quarries in Oxfordshire, I found, in one of the pits, only 20 feet of clay[15]. The general thickness is stated by Mr. De la Beche to be 500 feet[16].

Oxford oolite.—On the coast near Weymouth, 150 feet[17]. The whole, in Wiltshire, according to Mr. Lonsdale, about 200 feet[18]; Mr. De la Beche, 150 feet[19].

Oxford clay.—On the Dorsetshire coast, near Weymouth, 300 feet[20]: at Lynn in West Norfolk Mr. Rose assigns to this formation the whole depth of a well, which would make the thickness about 630 feet[21]; but part of this depth may possibly be Kimmeridge clay. Mr. De la Beche's estimate for the whole formation is 600 feet[22].

(164.) *Order of Geological Events.*—The succession of events which the preceding pages demonstrate, has been already detailed in some other publications*; but they are too important not to be recited here. The evidence bearing on the following propositions, derived from the South Eastern Coast, the Vale of Wardour, and Buckinghamshire, is all in perfect harmony; and the inferences are so directly connected with the facts, as to be rather corollaries than deductions from them.

1. Deposition, beneath the sea, of the following groups of strata, beginning with the lowest:—
   a. Oxford oolite. *b.* Weymouth and Kimmeridge strata. *c.* The Portland sand and stone.
2. Elevation of the Portland strata above the sea.
3. *Submersion*, by fresh water, of the newly disclosed land.
4. Deposition beneath fresh water, above the Portland strata,—first, of a thin bed of clay; and then of a crust of freshwater limestone, the "skull-cap." (111.) p. 224, and (113.) p. 226.

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[1] Supra (132.), p. 251. [2] (150.), p. 285-6. [3] Tabular View. [4] Webster, Geol. Trans. vol. ii. p. 42, 43; and Pl. VI. fig. 3. [5] Buckland and De la Beche, Pl. III. fig. 1. of this volume. [6] Supra (141.), p. 267. [7] (144.), p. 276-277. [8] (148.), C. p. 280-1. [9] (152.), p. 288, 290. [10] (106.), p. 212.—Section, fig. 5. Plate X. b. [11] Buckland and De la Beche, p. 19. of this volume. [12] Supra (148.) p. 282-3. [13] Page 19. of this volume.—This estimate, however, appears to be too great: see above, (107.) p. 212-13. [14] Pl. III. of this volume, fig. 1.; and p. 22, l. 6. [15] Supra (146.), p. 278-9. [16] Tabular View. [17] Buckland and De la Beche, p. 23. of this volume, l. 2. from bottom. [18] Geol. Trans. 2nd Series, vol iii. p. 261. [19] Tabular View. [20] Buckland and De la Beche, p. 28. of this volume. [21] Rose, p. 174.; supra (161.) p. 316. [22] Tabular View.

* See the works of Mr. Mantell; Dr. Buckland's and Mr. De la Beche's paper in the present volume; and the "Geology of Hastings", p. 79, &c.

5. Deposition upon the "skull-cap" of a bed of "dirt", (110.) p. 223.; and exposure of it as dry land.
6. Growth upon this land, of the Cycadeæ now found in the Dirt-bed, *in situ*, and in the upright position. 10: p. 223-4.
7. *Second submersion* (at least), of the land, in fresh water; proved by the deposition and existence of the "cap". (111.) 9, p. 222, 3; and (113.) p. 226.
8. Exposure of the surface of this "cap" as land; and growth upon it of coniferous trees, and of Cycadeæ. (111.) 8, p. 220-22.
9. Ravages (from the effects of currents of wind, or water,—or from earthquakes), by which the trees were overthrown, or broken off at short distances above the roots.
10. *Third submersion*, in fresh water; and deposition of slaty limestone, containing freshwater fossils only, but near the bottom alternating with clay*. (111.) p. 219, 220.; and (113.) p. 226.
11. Alternation of Oysters with freshwater fossils in the slaty Purbeck limestone; proving access of the sea†, apparently in an estuary (104.) p. 208; and (113.) p. 226.
12. Continuance of the estuarine condition during the whole remaining epoch of the Wealden; proved by the occasional presence of oyster-shells, throughout the Hastings-sands and Weald-clay. (98.) p. 190.; and List of Fossils, p. 178.
13. Sudden, or rapid, depression of the entire Wealden, to such a depth as to be covered with salt water; proved by the sudden and exclusive appearance of marine productions and fossils, above and in immediate apposition with strata containing only freshwater fossils, though mineralogically of the same composition, (100.) p. 196-7.

(165.) *Local Distribution of the Strata.*—If a line drawn from the coast at Folkstone, touching London on the north, and thence towards Newport Pagnell; and another line from about Atherfield in the Isle of Wight towards Faringdon in Berkshire, the tract intervening will comprise the space throughout which the beds immediately below the chalk are most fully developed: and if the standard be taken from the condition of the strata when possessed of their greatest bulk, that of the Green-sands and Wealden may be said to occur in Kent, Sussex, and the Isle of Wight; from which central tract these groups appear to thin out in every direction.

The whole series immediately below the chalk is finely developed between

* The alternations, in this case, are distinguished from those of the coal formation, (in which also the remains of terrestrial and freshwater productions alternate—in some instances repeatedly—with those of marine origin), by the *growth of plants upon the surface* of some of the alternating strata; a proof of their exposure, as dry land, between successive immersions. Mr. Prestwich, in a valuable paper on the coal-field of Coalbrook Dale, has justly remarked, that the repeated alternations in that district are no proof that the tract itself was *raised above the sea and again depressed*, as many times as the freshwater remains alternate with the marine;—since the facts may be accounted for by supposing that the strata were accumulated in an estuary liable to freshes from a river of considerable size.—Proceedings of Geol. Society, 1836, vol. ii.

† Lamarck (Animaux sans Vertèbres, vol. vi.) mentions altogether 81 species of the genus Ostrea; 48 of which are of existing species, 33 known only in the fossil state. Of the 48 recent species, 40 are marine, and 8 uncertain, but also probably marine. In the present state of our knowledge therefore, the occurrence of Oysters may fairly be considered as proof of the former access of the sea.

Farnham and Petersfield and around the west end of the Wealden denudation; the Lower green-sand, especially, is nowhere better disclosed, except in the Isle of Wight. It is not improbable, that the part of these groups which once intervened between the Isle of Wight and the Sussex coast, and is now concealed by the sea, was likewise fully expanded; but at Folkstone the Upper green-sand has already become much thinner.

It remains yet to be ascertained whether in their prolongation northward in England, and towards the east on the continent of Europe, these groups again assume their more bulky and varied form, as our Upper green-sand is observed to do after reduction, even within very short distances; and whether, if they do so expand, the relative proportions of the component members be the same in remote countries; an inquiry which is the more interesting in the case of the green-sand formation, from its very wide diffusion, and the great space which it occupies in different parts of Europe.

Details.—The following are some of the local variations in the strata composing the groups above referred to:—

Chalk.—It may be remarked that the chalk rises much more rapidly towards its outcrop, between Wiltshire and Hertfordshire, than in the more northern counties of the South East of England. In departing from that central tract, both towards Devonshire on the south, and northwards, the rise is comparatively small; the beds shooting out very gradually, and occupying very wide spaces of uniform, flat country. The disturbance, by which the ridge of the Wealds and the parallel range of elevations through the Isle of Wight and Dorsetshire were produced, was probably the principal cause of this variation: and the mean course of the Thames itself, from the point where it cuts through the chalk, may possibly be connected with that derangement. But in the chalk itself, on the south-west of London, much local variation is found in the angle and direction of the dip; and from the facts mentioned by Mr. De la Beche, respecting the faults in Devonshire, and what I have seen of the minor irregularities on the shore near Hastings, it is probable that if the whole surface in this part of England were examined with equal attention, it would prove to be pervaded by cracks and slight dislocations.

The *Upper green-sand* is especially remarkable for great variation in its thickness and composition; and it is everywhere so intimately connected with the lowest beds of the chalk, that if we had more accurate measurements of our strata, the *total* thickness of that formation, including the Upper green-sand—might, perhaps, be found to be nearly uniform. The latter passes most commonly by insensible gradation into the soft dark-coloured marly chalk. In many cases, it forms a very thin and scarcely distinguishable group,—as near Folkstone, where it is not more than 20 feet thick; in others, the chert which it contains becomes conspicuous, and it affords also beds of firestone, which together giving it firmness and durability, cause it to project as a step or prominence beyond the foot of the chalk range.

On the west of Portland, the green-sands thin out so rapidly, that at Blackdown a series about 200 feet thick is their only representative; and it is difficult to decide whether this be a condensed equivalent, of the whole group between the chalk and the lowest green-sand,—or, (which seems to be more probable,) only a continuation of the lower part of the *Upper* green-sand, from the Vale of Wardour. In following the range of these formations towards the north-east,

a similar reduction of the green-sands is observable, as the section at Hunstanton remarkably proves; but the diminution is by no means uniform throughout the intermediate space. Along the coast of Devonshire, the beds at the bottom of the *upper* sand seem to adopt the characters which the Lower green-sand exhibits in other places; and the latter, as well as the usually intervening gault seems to be wanting. In the Vale of Wardour also, where the Lower sand is scarcely apparent, the Upper green-sand exhibits many of its characters; but the Gault is very distinct between them.

The *Gault* is seen in the greatest perfection on the coast at Folkstone, where its fossils are especially beautiful and numerous. It seems to be thinner and to contain few fossils in the Isle of Wight, and is almost wholly wanting on the west of Purbeck. But in the interior—in the Vale of Wardour, and thence northward to the sea at Hunstanton,—this stratum everywhere appears, and contains throughout many of the same fossils, though it changes its character and is much reduced in bulk in Norfolk.

The almost constant presence of this distinct band of clay between the chalk and Lower green-sand, considering its small relative thickness, is a remarkable fact: and its retention, both in England and on the Continent, of the same mineralogical characters and fossils, renders the Gault a very important member of the series. I have seen it in its proper place, and in the form of bluish clay, all around the Lower Boulonnois; in the vicinity of Aix-la-Chapelle; and in the country between that place and Liege.

The *Lower green-sand* thins out remarkably towards the west, from the central tract just mentioned, (p. 321-2.). The traces of it in the Vale of Wardour are obscure, but they become gradually more distinct towards the north. The subdivisions of the Kentish coast, detailed in (16.) to (35.) and in Sussex (72.), deserve comparison with the more expanded equivalents of this formation in other countries. Their existence in the Isle of Wight is almost certain; and they will probably be found in Bedfordshire: but thence, north-eastward, the sands again become thinner, though they still preserve their relative place.

The Wealden.—This group, also, is best developed near the central tract already pointed out. The Weald-clay is seen in the greatest perfection in the Isle of Wight; and the Hastings-sand in the Forest ridge of Kent and Sussex, &c. But the Purbeck strata are fully expanded only in the Isle of Purbeck, and on the adjacent coast of Dorsetshire. No traces of any member of this group have been found west of the Isle of Portland; nor eastward of that island, near the coast, except in the vicinity of Battle in Sussex. In the Vale of Wardour, the Weald-clay and Hastings-sands are reduced almost to nothing; and they have not yet been found along the line of the green-sands between that place and the neighbourhood of Oxford*. Thence, to Quainton and Whitchurch in Buckinghamshire, the representatives of the Purbeck strata, though perfectly distinct, are but a few feet in thickness, and belong to the lowest beds of the formation. Other indications of the Wealden may be looked for, north of Whitchurch, in the detached portions of sand represented in Mr. Smith's maps of Buckinghamshire and Bedfordshire: and the specimens of Lonchopteris said to occur at Wansford on the north-east of Northamptonshire, (if they be really found *in situ*), would prove that the Hastings-sands exist at that place.

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* The subdivisions of the Wealden, especially at the upper part, being in some measure arbitrary, it is often difficult to determine which of the three groups any given portion of unconnected strata ought to be referred to. The same fossils pervade the whole; and beds of sand, clay, and stone, almost identical may be produced from all parts of the series; so that collective evidence alone can be resorted to for the purpose of distinction.

The places beyond the limits of the tract described in the preceding pages, in which the existence of the Wealden has been ascertained, or rendered probable, are mentioned hereafter, (168.) p. 326.

The sudden change from the marine fossils of the Lower green-sand to the freshwater productions of the Wealden is remarkably exhibited at Atherfield in the Isle of Wight (100.) p. 196; where the former stratum contains nearly thirty species, of about twenty genera; while the Weald-clay, not more than ten feet vertically beneath, contains scarcely any other shells than Cypris, Cyclas, and Paludina*. The contrast, in descending from the Wealden group, is equally striking and abrupt;—the Purbeck strata near their junction with the Portland affording scarcely any fossil but Cypris, while the "Roche" at the top of the Portland group, within a few inches of the freshwater limestone, is full of marine remains. (111.) p. 224.

The Wealden strata, though differing so widely as to their fossils, appear to be conformable to those of the adjoining formations, both below them and above. On the Dorsetshire coast, in the Vale of Wardour, and in Buckinghamshire, the Purbeck beds correspond exactly in dip and direction to the Portland stone beneath; and at Hythe in Kent, and in the Isle of Wight, the lowest beds of the green-sand are perfectly continuous with the upper beds of the Weald-clay, (98.) p. 189. The only place with which I am yet acquainted, where a want of conformity is indicated between these formations, is at Stopham in West Sussex, adverted to in (74.) p. 156. But the eroded cavities, filled with what seem to be green-sand and Fuller's earth, in the upper part of many of the quarries in Oxfordshire and Buckinghamshire, (of which those at Great Hazeley and Dinton are good examples,) indicate an interval and some intervening disturbance, between the periods of their production. (114.) p. 276; and (151.) p. 286.

(166.) *Theory of the Wealden.*—The mode in which the Wealden is disposed, in the South-east of England, accords with the hypothesis of its having originated in a lake of fresh water, or in the estuary of a large river. It remains to be determined whether similar deposits are found to occupy a corresponding situation in other parts of the great European basin, of which England is but a small portion.

The chalk and green-sands in England are so frequently prolonged beyond the limits of the beds below, concealing their outcrop, that no certain

* Woodward, so long ago as in 1702, pointed out the resemblance of the Wealden Paludinæ, to some recent freshwater species[1]: and Mr. Sowerby, about 1812, after mentioning their occurrence at Bethersden in Kent, remarks that "from these different localities of shells, appa-" rently of the same genus, we must conclude, either that analogy is not sufficient to prove that " these fossils are of freshwater origin; or else that there are more freshwater formations than " are generally supposed[2]". Mr. Webster, about the same period, distinctly mentioned the existence of freshwater shells in the Purbeck strata, and the probability that a part of that formation had been deposited from fresh water[3]. In 1822, Mr. Mantell reasoned with great sagacity upon the inferences derivable from the fossils, discovered by himself at Tilgate Forest[4]: but the geology of the strata connected with that group was then undetermined; and the difficulties, I believe, were not removed till 1824.

[1] "History of Fossils"; quoted by Webster,—Letters, &c., pp. 142, 192. [2] Min. Con. vol. i. p. 76. tab. 31. [3] Letters, &c. to Sir Harry Englefield, pp. 192. and 237. [4] Illustrations of the Geology of Sussex, 4to, 1832.

inference can be drawn with respect to the continuity beneath them of the Wealden and Portland strata. It is not improbable that what now appear to be detached portions, may in many cases be united; but it seems to be consistent with the mode in which freshwater deposits have been formed, whether in lakes or estuaries, that they should, in more extensive regions, occur in detached, rather than continuous portions; and that the outlines of the spaces which they occupy should be irregular. The former existence of the upper Wealden strata in the interior of England, is rendered probable by the erosion of the Purbeck beds in many places where the Lower green-sand comes into contact with them, (151.) p. 286,—which has clearly been effected by the action of water, and proves that something was carried away, before the sand was deposited: the argument from these appearances being the same as that derived from the erosions on the surface of the Oxford oolite and of the chalk, (143.) p. 274.

The great extent of the surface occupied by water in North America is a striking feature in every ordinary map. Dr. Richardson, in his observations on the geology of that region, has remarked that a large tract near the confines of the primitive and secondary regions is occupied by lakes of the most varied outlines and dimensions;—in which the deposition of shells and other exuviæ of organized beings has been going on ever since the surface of the globe assumed its present aspect. If that part of the northern hemisphere were now to be sunk beneath the sea, we should probably have, after a short time, one universal sheet of marine strata, lodged upon the surface of the present land, so as to conceal not only the deposits of the several lakes, but the intervals between them: and if we could, then, examine the internal structure of the tract, we should find it to be occupied by a numerous series of *Wealdens*, detached from each other, and bordered, it is more than probable, by deposits analogous to those of the dirt-beds of Portland, wherever the fluctuations of the lacustrine waters left time and space for the growth of plants upon their margin. The external boundaries of these deposits would be as various and irregular as that of the lakes which now diversify the map of North America: and we should expect, in such cases, that the mineral components in the deposits of the lakes, would vary according to the nature of the surrounding land. Their fossil contents would, probably, have a great general resemblance throughout large districts; but, in the remoter tracts would differ as much as the productions of modern lakes are found to vary;—as those of the lakes in the North of England differ from those of Switzerland, and both from those of the South of France, &c.; or, as in America, those of *Slave-Lake* differ from the productions of *Lake-Superior*

or *Lake-Erie.* The lacustrine deposits, again, would be occasionally diversified by the presence of the products of estuaries, such as those of the St. Lawrence and of other rivers around Hudson's Bay and the north-east coast of America; and in these we should probably find, along with the species of shells which usually inhabit the mouths of large rivers and the borders of the sea, some scattered remains of the products of the adjacent shores,—the plants and animals of the land, with some admixture of freshwater shells.

(167.) *Wealden in other Districts.*—The following are the places beyond the limits of the tract described in the preceding pages, in which the presence of the Wealden strata has hitherto been ascertained, or rendered probable.

Scotland.—In the *Isle of Skye* Professor Sedgwick and Mr. Murchison discovered, in cliffs of blue shale associated with trap, on the eastern shore of Loch Staffen, flattened masses of limestone, containing several species of shells; some of which are identical with fossils which I had found in the upper beds of the Weald-clay at Swanage Bay on the Dorsetshire coast; and all the rest are freshwater species belonging to genera found in the Wealden of the south*. The coincident species are the following; some of which are figured in the plates subjoined to these pages:—*Cyclas media* (Plate XXI. fig. 10.); *Cyclas*, a larger species (*C. major*, Pl. XXI. fig. 13., Isle of Wight); *Cyclas obovata*?; *Neritina Fittoni*, Mantell (Pl. XXI. fig. 7.); *Ostrea distorta*, found with Cyclades in the Isle of Wight, (Pl. XXII. fig. 2.); *Paludina elongata*; Isle of Wight and Swanage Bay; a transversely elongated Bivalve, (Isle of Wight); an *Unio*, or Anodon.

There can be little doubt, therefore, as Mr. Murchison has inferred, that this deposit was contemporaneous with the English Wealden.

Continent of Europe.—The places out of England, where the equivalents of the Wealden beds have hitherto been found, are the two following.

1. In the *Lower Boulonnois* the presence of the lower member of the group, at least, is certain; the strata being almost identical with some of those upon the confines of the Purbeck and Portland formations in Dorsetshire and the Vale of Wardour. Having given an account of that part of the French coast on another occasion†, it will be sufficient to mention here, that the line of the cliffs from Equihen on the south of Boulogne to Cape Gris-nez on the north of that place, is capped at intervals with a thin crust of the Purbeck strata, resting upon those of Portland, and consisting of slaty beds of limestone, which contain freshwater shells, and include a bed of tough dark-coloured clay, in which are numerous fragments of silicified coniferous trunks not distinguishable from those of the Isle of Portland. It is highly probable that a more exact examination of this part of the series, in the cliffs near Boulogne, may lead to the detection of these trunks in the upright position; and of the Cycadeæ by which they are accompanied on the Dorsetshire coast.

2. The *Pays de Bray*, near *Beauvais*, is a narrow tract on the line from Dieppe to Beauvais, extending in length, from the north-west of Neufchatel to the south of the latter city, a distance of about thirtyEnglish miles, and in breadth, at the widest part near the middle, about eight English miles. (See the annexed Map, Plate IX.) It is an opening, or valley of elevation, in the chalk,

* "Supplementary Remarks", &c., (1827,) Geol. Trans., 2nd Series, vol. ii. pp. 352 and 366.

† In a paper including some account of the Lower Boulonnis: See the abstract; Geol. Soc. Proceedings, Dec. 1826, vol. i. p. 9.

within which a very slight elevation of the central tract has brought into view the subjacent strata, as far down as those which immediately precede the representative of our Oxford oolite, with perhaps the mountain limestone beneath. I have not myself examined this interesting district; and the only publications relating to it that I have seen, are the report of the proceedings of the Geological Society of Paris during their excursion to Beauvais in 1831 *, and the splendid work of M. Passy on the Geology of the Department of the Lower Seine † :—but from the notes and sectional sketch of M. Cordier in the former of these works, and the full descriptions of M. Passy, there can be no doubt that the strata in the Pays de Bray are the same with the upper part of the series in the Lower Boulonnois.

The following is the order of the strata in the Pays de Bray, with what appear to me to be their equivalents in England; my list of equivalents, I am glad to find, coinciding very nearly with that of M. Passy himself ‡.

1. *La Craie.*—(Chalk).

2. *Glauconie sableuse de la craie.*—(*Upper Green-sand*).

Fossils said to be the same as of the Lower Chalk.

3. *Marne micacée et Marne bleue.*—(Gault).

Divisible, (at Ferte en Bray) into two portions:—1. Brown and micaceous. 2. Blue. At Meulin the *blue* marl is about 50 feet thick; it abounds in iridescent fossils, among which are, *Ammonites splendens*; *Hamites intermedius*; *Inoceramus sulcatus*; *Nucula pectinata*.

4. *Grès, et sable, Glauco-ferrugineux.*—(Lower Green-sand).

At Cap la Hêve are two beds of sand and ferruginous conglomerate, separated by a micaceous and glauconious marl. *Quæ.* the three subdivisions of Folkstone ? ?. At Forges and Neufchatel the ferruginous sand is 70 feet thick: it occurs above the Argile bigarée, mentioned hereafter, and contains, among other fossils, *Gryphæa sinuata*. At Les Friches de St. Germain is iron ore in grains, including small portions of ochreous hydrate of iron, with marine shells.

5. *Argile bigarée* (*Glaise Marbré.*)—*Variegated marl clay, and, sand,*—(*of* the Wealden; —or *Beds subordinate to the* Lower Green-sand.)

This deposit, which, according to M. Passy, is found everywhere in the Valley of the Pays de Bray, seems from the description to be very like the variegated sandy clay of the Wealden; but at St. Paul, near Beauvais, it is said to contain *marine* shells, the species of which, however, are not mentioned. Its place is commonly below the first stage of ferruginous sand and grit, and above the *Argile à fougères*; a situation corresponding to the place of some of the Wealden marls.

6. *Argile à creusets*; *Argile de Forges*; *Argile à fougères.*—(Weald-clay).

This clay in one place, at Neufchatel, is extracted by means of a shaft 70 French feet in depth, and occurs beneath sand of different shades, belonging to the Glauco-ferruginous beds, No. 4. above.

At St. Germaine la Poterie, a bed of slaty clay (lignite) is found, containing impressions of *Lonchopteris Mantellii*, and from one to two metres thick §: and among the beds found by M. Graves near Songeons, is one, described as "Marbre d'eau douce à Paludines," and referred by him to the *Purbeck* strata ||.

There can be little doubt, therefore, that some equivalent of the Wealden beds exists in this tract; but M. Passy appears to me to be in error when he is led, (no doubt by the indistinctness with which the strata are developed and exposed in the Pays de Bray), to regard the Wealden

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* *Bulletin de la Société Géologique de France*, 1831, p. 1. to 23.

† *Description Géologique du Departement de la Seine Inférieure*, 4to, Rouen, 1832.

‡ Passy, p. 237 to 272;—and Plates I. II. III. IX. and XVII. fig. 1.

§ Passy, p. 255. || Ibid., p. 257.

generally, in England, as no more than in a particular and subordinate bed of the Glauco-ferruginous sands*.

7. *Grès glauconnieux*; *Grès vert.*—(Portland-stone and Sand.)

These terms are applied to green-sand passing into grit, which again passes into a *calcaire glauconnieux*. Both the grit and limestone are full of green particles: they alternate with beds of sand, and are generally quarried throughout the Pays de Bray: and the *grès calcaire* is stated to be identical with that observed by M. Rozet, at Mont Lambert in the Boulonnois. Among the fossils are Ammonites; Crassatella; Cucullæa; Ostrea; Serpula; Trigonia; and teeth of the Diodon.

M. Passy justly expresses doubt whether this grit has hitherto been recognised in England. I believe it to belong to what I have proposed to call the Portland-sand; the characters and relations of which, though long since generally intimated by Mr. Conybeare, have not hitherto been fully understood in England: and, from my own observation, I have no doubt that some of the concretional masses of the Boulonnois belong to this part of our series. It will be observed, on comparing M. Passy's sections with those in the interior of England, that the lower *greenish* grit (Portland-sand) of M. Passy†, is not conformable to the beds above;—a fact analogous to the existence of chasms and "gullies", in the Lower Purbeck, and upper part of the Portland strata, in Oxfordshire and Bucks:—supra (111.), p. 218; (141.), p. 265; (144.), p. 276, (151.).

8. *Calcaire glauconnieux*;—a limestone composed of *fragments* of shells, united by sparry carbonate of lime, containing green particles, rolled grains of quartz, and flints of different hues. The fossils include *Ostrea gregarea*, and other indistinct species; *Trigonia*; and *Crassatella*. The limestone in this group alternates with grit, and includes a bed of green or bluish marl. The whole belongs to the group between the Portland-sand and the Oxford-oolite in the Lower Boulonnois and is represented in England by part of the series on the coast near Weymouth.

9. *Marne et calcaire marneux*;—*à Gryphæa Virgula*; *Calcaire lumachelle.*

The strata of this group are described as occurring unconformably—("étendues en couches discordantes"), beneath the ferruginous sands: a statement which accords with the relations of the group to the Upper green-sand,—but *not* to the sands of Portland. The formation is characterized by *Gryphæa Virgula*, and some of the beds contain *Ostrea deltoidea*. On the coast, from Havre towards Henqueville, it occupies a thickness of 30 metres (about 100 English feet), between the chalk and the oolite‡; and it seems to be the equivalent of the series of shale, limestone, and calciferous grit abounding in petrifactions, which connects the Kimmeridge-clay with the Oxford oolite, on the coast of the Boulonnois, and of Dorsetshire.

10. The lowest strata of the Pays de Bray "*consist of blackish compact limestone*, like that of "*Marquise* in the Lower Boulonnois;—*the carboniferous limestone of England*:" and these succeed immediately to the group last mentioned. If this be so, the oolitic series, from the Oxford oolite to the bottom of the lias, is wanting; together with new red sandstone and the coal formation:—another point of resemblance to the Lower Boulonnois.

(168.) *Marine deposits coeval with the Wealden.*—It is obvious that, during a period of time sufficient for the accumulation of the Wealden, the deposition of matter in the adjacent seas could not have been inconsiderable; so that we might expect to find, interposed between the strata which then formed the

* "....que l'argile Veldienne qui contient les coquilles d'eau douce, n'est qu'une couche "particulière de terrains glauco-ferrugineux d'Angleterre."—p. 256.

† Passy, p. 272; and Plates I. and II.

‡ Ibid., p. 262, 265.

bottom of the sea, and the Lower green-sand, a series of beds coeval with the Wealden in point of date, but differing from it in possessing the characters of a marine deposit, and including marine shells and other productions of salt water;—with which, near the shore, the productions of the land, or even the freshwater shells of the rivers, might be occasionaly intermixed. And if the Portland strata constituted at that epoch, both the dry land, and the bottom of the sea, and were afterwards submerged, we ought now to find the Lower greensand, in some places immediately in contact with the Portland,—in others with the Wealden,—and in others again with the marine equivalent of this latter group.

Two results would probably attend the state of things here supposed, which are deserving of notice: 1st, That the Wealden and its marine equivalent could not both be found in the same place; and consequently, (since we have the former in England), that the *marine* beds of that date are not to be expected generally in this country: 2ndly, That the marine fossils of the beds cotemporaneous with the Wealden would probably be distinct, both from those of the Portland group beneath, and of the Green-sands above them; a consideration which gives peculiar interest to the fossils of this intermediate group.

The strata between the chalk and the oolitic system on the continent of Europe have not yet been sufficiently examined, to furnish all the evidence that may be expected upon this subject; but indications of such an equivalent to our Wealden as has been mentioned, have been already found in so many detached points, that its occurrence in other places, or even the existence of a continuous marine deposit of that age, is by no means improbable. Mr. De la Beche* has brought together evidence which shows that such a group exists in the department of the Haute Saône, in France; at Candern, in the Brisgau; near Aarau; in Poland; and on the confines of Silesia. To these may be added the Isle of Bornholm in the Baltic, and the vicinity of Helsingburg, in Scania, which have afforded specimens of fossil plants resembling those of our Wealden, along with marine shells; but at Bornholm, although the shells are also marine, they are generally such as may be supposed to have inhabited, either the estuary of a large river, or the seas immediately adjacent to the coast.

In most of the cases mentioned by Mr. De la Beche, a group of strata between the chalk and the oolitic system is found to contain pisiform iron ore; but the fossils which accompany that mineral are marine. A very extensive deposit of this kind in Poland and Silesia is described by Professor Pusch, which includes also argillaceous iron ore; and among its fossils are the genera Ammonites,

* Geological Manual, (1833.), p. 309.

Cardium, Venus, Trigonia, Sanguinolaria. The pisiform ore of the Haute Saône appears from the statements of M. Thirria to be above the Portland strata; but its relations to the superior formations are less distinct. It contains Ammonites, Hamites, Nerinea, Cirrus, Terebratula, and Pentacrinites, with teeth of fishes and of Saurians: and it is observable that the uppermost stratum in the group supposed by M. Thirria to represent the Portland stone, is "a compact conchoidal "limestone, a little tubercular, which contains a species of Paludina? near to Vivipara fluviorum "of Sowerby;"—a description which might very well be applied to some of our Purbeck strata.

M. Walchner has ascertained that the pisiform and reniform iron ores of Candern, belong to two distinct formations, of very different date. The lower rests upon beds of "Jura limestone", which he refers to the Coral-rag or Portland-stone, and which are decidedly below the molasse of Switzerland. The second and more recent pisolitic deposit occupies eroded cavities on the surface of several different formations; it consists of transported matter containing fossil bones, and is not covered by any solid strata. M. Merian is cited by M. Walchner in support of this view of the relations of these deposits; but in the description given by the former, of the strata which immediately cover the pisiform ore of Aarau, there are features very like those of our Wealden itself: for they are mentioned as consisting of "grit and bituminous schist passing into lignite, and "containing a great number of petrifactions, among which, though commonly indistinct, are a "Planorbis, and other freshwater shells."

The doubt which obviously presents itself with respect to the evidence above mentioned, is, whether a formation thus contiguous to the green-sands, and so very nearly coeval with them, may not really be a part of that formation itself; the presence of some fossils distinct from ours, not being sufficient to prohibit this identification. But the peculiar character and abundance of the iron ore, are important circumstances of difference.

The evidence respecting Bornholm occurs in a paper read before the Geological Society by Dr. Beck of Copenhagen*, who states that the beds below the cretaceous group in that island, exhibit many of the characters of a coal formation, containing coal and numerous impressions of ferns, among which are several of the genus Pecopteris; and with these was found the seed vessel of a Restiacea, considered by Dr. Beck as identical with one from the Hastings-sand at Heathfield in Sussex, which he himself had seen in Mr. Mantell's collection. The existence in the vicinity of Hoer, of fossil plants *analogous* to those of the Wealden, but probably belonging to the oolitic series, had been previously pointed out by Mr. Adolphe Brongniart†: but from what has been very recently mentioned to me by Professor Nilsson of Lund, after he had examined some of our best collections of the Wealden fossils, it is probable that a deposit contemporaneous with that formation may be found at Helsingburg in Scania, between the chalk and green-sands which occur near the coast of the Baltic, and the Lias, known to exist on the north-west of that place

The observations of M. Boblaye in the north‡, of M. Desnoyers§ in the north-west, and of M. Dufresnoy||; in the south-west of France; with those of M. Elie de Beaumont, on the boundary of the Paris and London Basins¶; of Mr. De la Beche**, M. de Caumont††, M. Desnoyers‡‡,

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* "Proceedings" (1835-6) vol. ii. p. 217. † *Annales des Sciences Naturelles*, 1825.
‡ Ibid., 1820, t. xvii. p. 35. § Ibid., 1825, t. iv. p. 353. || Ibid., 1829, t. xvii. p. 192
¶ Ibid., 1829, t. xvii. p. 354. ** Geol. Trans. 2nd Series, vol. i. p. 13.
†† *Mém. de la Soc. Linn. du Calvados*, t. i. 1824, p. 49 et 67; t. ii. 1825. p. 447, &c.
‡‡ *Mém. de la Soc. d'Hist. Nat. de Paris*, t. ii. 1825.

M. Constant Prevost*, and M. Passy †, on the coast of Normandy and the adjacent district; and more recently of M. Thirria, in the department of the Haute Saône‡, have shown that many of the beds between the chalk and the oolitic system in the different provinces of France, agree with each other, and with those of England, perhaps as nearly as the more distant portions of the same formations are found to do in our country: the Portland strata, which form the lower boundary of the Wealden, occurring at several detached points along their course; while above them, the chalk affords a limit which cannot be mistaken. It may deserve the inquiry, therefore, of resident geologists, whether traces at least, of all the intermediate groups between the Portland and the chalk may not be detected generally along the line of connexion; and I am not without hope that the task of comparative examination may be assisted by the preceding pages.

Among the points deserving of notice by those who examine the beds below the chalk in districts imperfectly known, I would mention especially the characters of the *Portland Sand*;—from the facility with which that formation may be confounded with other sands, likewise charged with green particles. I have reason to believe that a neglect of the distinctions between these different sands, and a consequent ignorance of the distance by which they are separated in the series of strata, has produced difficulty, and led to much confusion in the arrangement of the groups between the chalk and the oolitic system.

(169.) *Beds below the Wealden.*—The groups next below the Wealden, in the tracts described in the preceding pages, are connected by several characters; the Portland sand forms a transition to the Kimmeridge clay; and the latter, at its lower part becomes charged with sand and calcareous matter, and passes insensibly into the Oxford oolite. The fossils, also, of these associated groups are very much allied, and there is no reason to suppose that the deposition of this part of the series was interrupted by any important change of circumstances.

Portland strata.—The space occupied by the Portland strata, so far as they have yet been discovered in England, is bounded on the west by a line passing from Portland to the outcrop of the Portland stone in the Vale of Wardour, and thence towards Swindon. On the east of that line the Purbeck and Portland formations are visible only in the remaining portions of the once-continuous sheet, which seems originally to have invested a great part of Oxfordshire and Buckinghamshire. Whether the Portland beds exist, or ever have existed, under the sands of the Isle of Wight, Sussex, and Kent, it is now impossible to say; though it is probable that they did so, from their occurrence on the opposite coast of France, and their thickness in that quarter.

The peculiar circumstance relating to the junction of this formation with the Purbeck beds, is the distinct character of superficial soil, which the bed in which the trees and Cycadeæ are found, exhibits in the Isle of Portland. Trees and plants have occurred in the upright position in many other places, and in other parts of the series of strata; but the soil in those cases had lost its recent character, and been in a great measure assimilated to the surrounding matter. Some other thin beds alternating with the lowest strata of the Purbeck limestone, have likewise more

* *Mém. de la Soc. d'Hist. Nat. de Paris*, t. ii. 1825. p. 389.
† *Sur le Département, &c.* 4to, Paris, 1833.
‡ *Mém. de la Soc. d'Hist. Nat. de Strasbourg*, 1830, t. i.

or less of the character of a mechanical agglomerate; but none of them approach to the gravel-like texture and composition of the "Black-dirt" of Portland and the adjacent coast.

The small extent which the Portland strata occupy with reference to the Kimmeridge clay, is a remarkable fact; showing either that the former, like the Coral-rag, was originally deposited in detached portions;—or that the portions of the Portland group that we now see, are only the remaining and eroded borders of one continuous coating originally lodged upon the clay.

It is remarkable, also, that the *Wealden* has not yet been found beyond the limits of the Portland group; never reposing, as the green-sands are frequently seen to do, on any of the formations beneath the Portland stone: but before this exclusion be adopted, it will be necessary to examine more completely the counties on the north of Buckinghamshire. Reciprocally, in all the places where the Portland beds have hitherto been found, one or more members of the Wealden group are connected with it. It is possible, therefore, that the Portland strata formed the only land, at the period when the freshwater beds of the Wealden group began to be deposited.

The *Kimmeridge clay* thus more widely diffused than the Portland and the Wealden, forms the continuation upwards, of a long series of alternate strata of oolitic limestones, sand, and clay. The extent, thickness, and development, of this formation, vary much in different places, the upper beds alone being visible at the point from whence the name has been derived. The relations of the groups are fully seen on the coast near Weymouth, and still more completely on the shore of the Boulonnois, and near Scarborough: but, although the clay extends, without interruption, from Dorsetshire to Norfolk, it is seldom seen to advantage in the interior of England. Near Oxford, the lower members, which form the transition from the bituminous clays of Kimmeridge to the Oxford oolite, are evidently wanting; and the surface of the calcareous reestone beneath the clay, is deeply worn and eroded.

(170.) *Composition of Strata.*—Among the circumstances relating to the composition of the strata above mentioned, below the chalk in the South-East of England, the following are deserving of attention.

1. Proofs of the formation of stone, in the midst of strata of gravel, sand, and clay, distinctly of mechanical origin. This fact, which is of universal occurrence throughout the series of secondary strata, is especially remarkable in the Lower green and the Hastings sands of Kent and Sussex: sex: the former containing masses of siliceous grit, chert, and chalcedony, and concretions of chert, evidently formed subsequently to the division of the beds which inclose them, yet traversed by the same lines of false stratification which pervade the looser matter:—(22.) and (23.)

2. The change, in the fossil trees of Portland, of the original woody substance into silex; and the contrast of their composition with that of the surrounding matter in the "Dirt-bed", in which fragments of soft limestone are abundant; the strata, both above and below, likewise, consisting principally of carbonate of lime. In the Lower green-sand also, at Woburn, the petrifying petrifying matter of the coniferous wood is silex*.

3. The shells preserved in the green-sands of Kent, consist of carbonate of lime; but in the sands of Blackdown, though shells occur in still greater numbers, the calcareous matter has almost entirely disappeared, and with very few exceptions has been replaced by chalcedony; and the surrounding sand, instead of effervescing with acids, imbibes them tranquilly.

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* The fact remarked by Mr. Brown, that all the fossil wood hitherto discovered in the strata mentioned in these pages, is either monocotyledonous, coniferous, or cycadeous, has been already adverted to: (112.) p. 225.

4. The occurrence of oolite containing freshwater shells, near the bottom of the Purbeck strata at Combe Wood (144.), p. 275-6, is another fact deserving of notice, and may perhaps explain some doubtful appearances in the uppermost bed of the Portland Series (the *Roche*); which, although full of marine petrifactions, and commonly oolitic, has very much the aspect of freshwater limestone. It can easily be imagined that the bank, or land, consisting of the Portland strata, when first raised above the sea, was covered with marine remains, which might subsequently have been cemented together, at the bottom of a freshwater lake.

5. The existence of pisolitic (or granular) oxide of iron, in the Wealden, is probably not confined to the coast near Hastings, where I found it to be generally diffused; p. 166. The fact of its occurrence in this formation is the more deserving of notice, from the great abundance of that ore in the *marine* deposits supposed to be contemporaneous with our Wealden, in other parts of Europe: supra, (168.) p. 330.

(171.) *Similarity of Deposits of different Epochs.*—The mineralogical resemblance between some of the strata above and beneath the Wealden, is very remarkable.—The upper part of the Portland formation in the Vale of Wardour is so like chalk, that it bears that name in some of the quarries; and both there and upon the coast of Dorsetshire it contains flint nodules, not distinguishable from those of the chalk.—The Portland sand abounding in green particles, cannot, in itself, be distinguished from the green-sands above the chalk, nor from those below; the green matter in all is of the same nature; the calcareous concretions are like those of the "Kentish-rag": yet the deposition of these groups was separated by intervals of time sufficient, in the first two cases, for the accumulation of all the Wealden strata, and in the two latter, for that of the chalk.—The strong resemblance of the variegated sands and marl of the Wealden to those of the new red sandstone, and of both to the tea-coloured and variegated marls of the beds above the chalk in the Isle of Wight, has been already mentioned. —The Wealden, again, has many striking points of resemblance to the coal measures. The shale, sandstones, and clay iron-stone of the latter are not distinguishable from those of the Hastings-sands, which are, in fact, a coal formation: and in addition to the Unios and other freshwater shells long known in the coal formations, the recent discovery of Cypris, in freshwater limestone, among the coal measures in Scotland*, is another point of agreement.

These resemblances, of which other examples might easily be given, in deposits separated by great intervals of time, demonstrate the identity of the processes which are still going on with those of the more ancient epochs,

* See, however, upon this subject, the remark of Mr. Sowerby, as to the possible resemblance of the fossil crusts of the *marine* genus Cytherina, to those of Cypris: Appendix, p. 345, under the head *Cypris Valdensis.*

and prepare the mind for the reception of other proofs of that continuity of action, which has of late been so ably discussed.

(173.) *Fossils.*—A systematic list of all the fossils mentioned in the preceding pages* is given in the Appendix B: and I have connected with it a series of columns, exhibiting at one view the stratigraphic distribution of the several species. My collection is so incomplete, that many of the columns are unoccupied; and most of them afford very inadequate representations of the facts: but it will be advantageous to keep in view the completion of such a list, whenever sufficient materials shall be obtained to fill it up. The number of specimens collected from any given district or series of strata, depends on so many circumstances purely accidental,—the texture of the matrix, the number of open quarries, the relative skill and activity of collectors,—that the richest collections can very seldom be regarded as fairly representing the fossil contents of the groups from which they are obtained; and there still are large tracts, in every part of the English series, the fossils of which are unknown. The proportion, therefore, which the species we are acquainted with, bear to the whole number contained in the strata, is so far from being determined, that any general reasoning upon this subject at present would be of little value.

From the imperfect lists of fossils given above, it would seem that even short distances are attended with greater variation in the contents of the strata, than might have been expected; and that although some species pervade the whole range of the formations in which they are found, others occur in several of the tracts described which have not yet been obtained elsewhere.

I cannot conclude these pages without expressing my great obligation to Mr. Lonsdale, for his kind and unremitting assistance during their passage through the press; which has been doubly acceptable, from its having been conferred on me by one of my most valued personal friends.

W. H. F.

London, August 16, 1836.

* It may be proper to mention here, that the whole of the author's collection referred to in the preceding lists, has been presented to the Geological Society, and will be found in their Museum.

APPENDIX.

APP. A.

Descriptive Notes respecting the Shells figured in Plates XI. to XXIII. *By* James de Carle Sowerby, F.L.S. &c.

PLATE XI.

Fig. 1. *Tornatella elongata.* Elliptical, elongated; surface furrowed; furrows crossed by short lines; whorls about four; lip slightly thickened. This resembles *Acteon* (*Tornatella*) *simulatus* (Min. Con. t. 163. f. 2.) of the London clay, even in the dotted furrows upon the surface of the shell, but it is much longer in proportion, and is only half the size.

Fig. 2. *Lucina? globosa.* A nearly globose smooth shell, with the lines of growth peculiarly waved near the posterior margin. I have not seen the interior.

Fig. 3. *Avicula Gryphæoides.* The convex valve nearly orbicular, with a projecting incurved beak, and two small unequal ears: when alone, it may easily be mistaken for *Inoceramus concentricus*, but the parts about the beak, especially the ears, show the difference. The other valve is nearly flat, orbicular, and has one small and one large ear. The convex valve *a.* is represented from specimens found at Nursted in Hampshire; the other valve, *b.* is from Cambridgeshire.

Fig. 4. *Pentacrinus.* The stem only has yet been found; it is various in size, the sides are concave, the angles rounded. Joints equal, the margins of their surfaces ornamented with short striæ. Some specimens show the bases of lateral arms. It strongly resembles a species found in the chalk;—(Mantell; Fossils of the South Downs, p. 183; Geol. of the S.E. of England, p. 112.); which is, however, much larger.

Fig. 5. *Pollicipes lævis.* The lateral valves are rhomboidal, smooth, thin, and nearly flat: in the partially decomposed state in which they are found, they appear to be composed of layers, of different degrees of transparency and depths of colour. This species also occurs in the greensand at Blackdown: see Plate XVI. fig. 1.

Fig. 5*. *Pollicipes unguis.* Smooth, the valves are all remarkably curved, and broad in proportion to their length.

Fig. 6. *Pollicipes radiatus.* Valves wedge-shaped, flat, marked with sharp, elevated rays, diverging from their apices.

Fig. 6*. *Pollicipes rigidus* is distinguished by thin transverse elevations, which are very prominent upon the posterior valves: the lateral valves are elongated.

Fig. 7. *Venus? tenera.* Shell lenticular, rather transverse, neatly marked with concentric striæ; lunette lanceolate.

Fig. 7*. *Venericardia tenuicosta.* Transversely oblong, approaching to square. It varies much in convexity: and when old or interrupted in its growth, is nearly globose, rather heart-shaped. Specimens have been found twice the length of that represented in the figure, both of the oblong and globose form. The surface of the rays is rough, with slightly elevated obtuse scales. The interior of the margin is crenated. Lunette rather deep, heart-shaped.

Fig. 8. *Nucula bivirgata.* Very convex; the surface ornamented with two sets of linear furrows, which meet towards the posterior slope, at acute angles directed towards the beak of each valve; the junction producing a regular line, without forming a ridge. Lunette broad.

Fig. 9. *Modiola bella.* Neatly striated, convex, with parallel edges, nearly equal sides, and obtuse beaks.

Fig. 10. *Lima semisulcata.* (*Plagiostoma semisulcatum*, Nilsson, Petrif. Suec. 25, t. ix. f. 3.) Ovate elongated, very convex, the beaks incurved, short; ears nearly equal, small. Where the lines of growth cross the ridges, which vary in number from 11 to 16, they form obtuse, short scales or grains.

Fig. 11. *Auricula inflata.* (Benett's Catalogue of Wiltshire Fossils, 4to, p. 2.) Shell ovate; spire small, pointed; the last whorl large; aperture at the lower part approaching to square, but with one of the upper angles elongated and acute; the lips united, thick, obtuse; the columella has two plaits, the lower sometimes divided by a groove along its middle. The surface of the shell is marked with numerous spiral lines of elongated punctures. The thick lip separates this from several species of Tornatella, to which in other respects it bears a strong resemblance. *Auricula incrassata* of Min. Conch. t. 163. is shorter and smaller, and has the lip more enlarged. *A. incrassata* of Mantell (Geol. Sussex, t. xix. figs. 2, 3, and 34.) also resembles it, but has a much shorter spire.

Fig. 12. *Natica canaliculata.* (*Ampullaria canaliculata*, Mantell, Geol. Suss. tab. xix. fig. 13.) Globose, depressed, smooth. Umbilicus large, circular, gradually expanded into the base. Around the upper edges of the whorls is a concave, transversely striated groove, best defined in the young shell,—as in *c*. The inferior specimen, *a b*. is filled with brownish phosphate of lime. See the figure of a much larger specimen, Plate XVIII. fig. 6.

Fig. 13. *Solarium ornatum.* Discoid, with a small portion of the spire elevated and acute; aperture rhomboidal. Surface, above ornamented with obtuse, radiating ribs,—and near the margin, both above and below, with granules in quincunx order.

Fig. 14. *Solarium conoideum.* (Min. Conch. t. 11.) A conical shell as high as it is wide; the umbilicus large and smooth. The outer coat of the shell is represented in this figure; and shows the upper part of each whorl to be concave, and elegantly marked with decussating striæ forming rows of granules; aperture rhomboidal, nearly square.

Fig. 15. *Pyrula Smithii.* Ovato-fusiform; two obscure keels and numerous striæ wind round its surface; spire rather elongated, acute. These two figures, perhaps, represent different species: fig. *a*. is more distinctly keeled than fig. *b*., which, however, being considerably worn, has lost much of its external sculpture; but shows also longitudinal undulations, which can hardly be traced upon fig. *a*. Both the specimens are from Copt Point, near Folkstone. *Murex Smithii* (Min. Con. 578), lately removed to the genus Pyrula, is a different shell.

Fig. 16. *Rostellaria elongata.* Presumed to be a Rostellaria, from its resemblance to *R. marginata*, fig. 18.; from which it differs principally in its great length and the smaller number of ribs. Turrited, much elongated, ribbed, transversely striated; upper edge of the whorls smooth.

Fig. 17. *Rostellaria buccinoides.* A neat, subulate, costated shell, approaching to *R. rimosa*: it has but one varix upon each whorl: the lip is not lobed.

Fig. 18. *Rostellaria marginata.* Turrited, conical, transversely striated; ribs eight or ten upon each whorl, short and obtuse; last whorl keeled, without ribs. Named from a ridge or narrow band upon the upper edge of each whorl; which is more or less conspicuous in every specimen, and assists in distinguishing the species from *Rostellaria Parkinsoni*. See Pl. XVIII. fig. 24.

Fig. 19. *Rostellaria carinata.* (Mantell; Fossils of the South Downs, p. 86, Pl. XIX. figs. 10, 11, 12, and 14.) This figure, from a drawing by the Rev. G. E. Smith, exhibits the lip in an advanced stage of growth. The spire is nearly subulate, composed of eight or nine convex whorls; a row of small tubercles, or short ribs, winds round the middle of each whorl except the last,

which has two acute keels; the lip has a long forked projection arising from the upper keel; the beak is long and subulate; the whole surface striated.

Fig. 20. *Ammonites? circularis.* Aperture circular; whorls just touching each other: nearly close, acute, circular; sometimes forked ridges cover the surface. This specimen may, perhaps, be a portion of an Hamites or Scaphites?

Fig. 21. *Ammonites symmetricus.* Aperture nearly square; ribs blunt, slightly tumid as they approach the hollow in which the rounded keel is immersed, and though not equal in length, elegantly uniform in their elevation; the sides of the whorls flattened. The specimen here figured, though a fragment only, differs from every Ammonite known to me.

Fig. 22. *Ammonites crenatus.* Sides flattened; the inner whorls much exposed, their margins nearly smooth and rounded, those of the outer whorls crenated on each side of a narrow concave space over the siphuncle. Distinguished from *A. splendens* by the more exposed inner whorls.

Fig. 23. *Ammonites cristatus.* (De Luc, in Brongniart, Env. de Paris, pl. vii. 10.) Some of the ribs being acute and much more elevated than others, form the distinguishing character of this species. I believe *A. cristatus* and *A. subcristatus* of De Luc to be varieties of the same species: I have seen both from Folkstone: the specimen before us belongs rather to the latter variety.

PLATE XII.

Figs. 1, 2. *Hamites rotundus.* (Min. Conch. tab. lxi. fig. 2, 3.) The peculiar structure of the inner extremity in this species, is indicated, rather than distinctly seen, in these figures; which have been engraved from drawings by the Rev. G. E. Smith, taken from specimens collected by Lord Greenock, near Copt Point in Kent. Mr. Smith observes, in a note sent with the drawings, that the termination in a minute whorl, (imperfectly seen in the figures,) had been traced distinctly in more than one specimen; which proved that the coils of the spiral were nearly parallel to the straight part of the stem, and the axis at right angles to it. The spiral appears to have been open, as in many recent Serpulæ; so that its perfect preservation in the fossil could scarcely have been expected: and this would account for the defective state in which the Hamite is commonly found. Mr. Smith adds that the spiral portion appeared invariably to have been decayed, as if it had been filled up with soft matter, as in the case of Magilus. The figures show the remains of the spiral, in two different specimens; but in both much broken and displaced. The spiral part is round, with contiguous annular ribs, also round and regular.

Fig. 3. *Hamites attenuatus.* (Min. Conch. t. lxi. fig. 4. and 5.) Both ends of this species, when complete, are similarly bent or folded in, not spirally, but so that the segments become parallel to each other. The larger parts are rather compressed, the smaller cylindrical; the ribs are annular and rounded.

Fig. 4. *Hamites spiniger.* The general form of this species is like that of *Scaphites Yvanii,* (Bull. de la Soc. Géol. de France, vol. ii. p. 355, pl. ii.); one portion being a flat volute, like an Ammonite, but with unconnected whorls; the other bent into the characteristic form of a Hamites: the sides are flattened. The spines form one of the chief specific characters: there are three rows of them on each side, placed upon the larger ribs on the involute part of the shell; they are gradually lost upon the other parts.

PLATE XIII.

Fig. 1. *Echinus? arenosus.* The underside is imperfect, and the genus therefore doubtful.

Fig. 2. *Panopæa rotundata.* Only a cast, which is nearly smooth. The ridge separating the posterior area, which is small, is strongly marked, and projects on the margin.

Fig. 3. *Trigonia spinosa*, var. Distinguished from *Trigonia spinosa* (Min. Conch. t. lxxxvi.), of which it is a variety, by the presence of longitudinal ridges continued from the bases of the spines, and by its more oblique form. It is often longer than the specimen here figured.

Fig. 4. *Diceras Lonsdalii.* The small portion hitherto examined of the external impression of this curious fossil, shows the shell to have been squamose, like an Oyster, and of considerable thickness. The two valves are less equal in size than is usual in the genus Diceras. The larger valve is an elongated cone, rather flattened and curved twice round; and it appears to have been attached to some foreign body, as in *Diceras arietinum.* The other valve has only an oblique conical umbo.

PLATE XIV.

Fig. 1. *Pholas giganteus.* In general aspect much resembles a Pholadomya; but the apparently squamose structure of the surface shows it to belong to the same section of the Pholades as *P. candidus.* Its valves are so convex as to form nearly a cylinder when closed. The reflected margin near the beak, so large in some Pholades, is probably broken away in this specimen.

Fig. 2. *Modiola lineata.* The depth of each valve is equal to its width; the beaks are obtuse; the margins are arched and nearly parallel; the surface longitudinally and finely striated.

Fig. 3. *Avicula pectinata.* A slightly convex shell, with large, square, depressed ears, and short acute linear ridges, alternately longer.

Fig. 4. *Ostrea retusa.* This, like most Oysters, is very variable in form, but generally much curved and nearly orbicular; the shell is moderately thick, plain in the middle, but strongly plicated at the margin with angular plaits. It occurs in massy groups. It is not so flat as *O. semiplana*, a fossil of the chalk; nor are its valves so equal, nor so thin, as in that species, which it otherwise much resembles.

Fig. 5. *Anomia radiata.* Irregularly orbicular, flat, finely radiated. The radii are coarser, and more distant, than the fine striæ which occur in the London clay species, *Anomia lineata*, (Min. Conch. t. 425.)

Fig. 6. *Anomia lævigata.* Much smoother, and more even, than any other known species: very thin, orbicular, and flat. The figures *a.* and *b.* are taken from different specimens; *a.* in Mr. Smith's collections; *b.* in Mr. Sowerby's.

Fig. 7. *Anomia convexa.* A remarkably convex species, with a large and prominent beak, and smooth surface. The furrows are produced by a Terebratula to which this specimen was attached, and to which it consequently bears a great resemblance.

[The name of this new species has been omitted, by mistake, in the list of Lower green-sand fossils of the Isle of Wight, p. 204. It was found there in the debris fallen from the cliff, on the shore east of Shanklin Chine.]

Fig. 8. *Terebratula Tamarindus.* Nearly orbicular, smooth; margin very obtuse. Disk rather flattened; beaks but little curved, with an angular, slightly prominent ridge on each side, passing down the sides of the valves.

Fig. 9. *Terebratula quadrata.* Ovate, gibbose; beak large; front broad, straight, with a few large plaits.

Fig. 10. *Terebratula Faba.* Elliptical, narrow, gibbose; front concave, but not elevated, very narrow; the perforated beak short, but prominent.

Fig. 11. *Terebratula elegans.* Transversely obovate; beak prominent, pointed, nearly straight; plaits numerous, sharp; front slightly elevated, straight.

Fig. 12. *Terebratula convexa.* Angles rounded; valves very regularly convex; beak large; plaits numerous, rounded; front slightly elevated.

Fig. 13. *Terebratula parvirostris.* Imperfectly tetrahedral, rounded; beak small, sharp; sides slightly produced and angular; plaits numerous, angular; eight or nine of them much elevated in the front.

Fig. 14. *Terebratula prælonga.* Ovate, much elongated, gibbose; front slightly elevated, with a depression in its middle; beak prominent, large; surface smooth. The figure *a.* is from a drawing by the Rev. G. E. Smith; *b.* from another specimen, also found near Sandgate.

Fig. 15. *Lingula? truncata.* Ovate, depressed, flattened most along the middle; front straight.

Fig. 16. *Pleurotomaria gigantea.* (Trochus; British Mineralogy, t. 403.) Conical, height and breadth equal; whorls slightly overlapping each other; sides straight; surface concentrically striated. The transversely striated band proceeding from the deep sinus in the lip, which marks the genus, is well preserved on a specimen seven inches in diameter, in the collection of Charles Manning, Esq., who obtained it from near Hythe, after this plate was engraved. Some specimens of this shell are so much changed by pressure as not to be above one inch high, while they are three or four inches in diameter, with a sharp margin.

Fig. 17. *Ammonites furcatus.* Discoid, sides and front flat; inner whorls partly exposed; aperture with a square front, oblong, deeply impressed with the preceding whorl, lateral angles truncated; ribs not very numerous, thick, curved, many of them forked, passing at right angles across the front.

PLATE XV.

*Scaphites Hillsii**. General form obovate, compressed; the inner whorls exposed, not touching each other, but still curved into a regular volute, compressed, bearing numerous small, close, rounded ribs: the outer whorl strikes off from the others, in nearly a straight line, to a considerable distance, and then bends back so that the aperture nearly touches the preceding whorl, furnished with ten or more distant, very prominent, sharp-edged ribs, which are most raised upon the sides. Aperture nearly square, thin-edged, preceded by a short rib over the front; Siphuncle small, close along the front, or outer margin of the whorls; septa much sinuated, not very close. The system of inner whorls occupies rather more than half the longest diameter of the entire shell, which is about fourteen inches.

Fig. 1. represents a specimen of the inner whorls, reduced to half the real diameter. A small Exogyra was found attached to the inner margin of one of the whorls of this individual, showing that there was always a space between it and the next whorl.

Fig. 2. is drawn from a portion of an outer whorl, also half the natural size. The specimen is irregularly flattened.

The above description has been made from several nearly entire specimens, obtained from the vicinity of Maidstone after this plate was engraved, and now in the possession of Sir Philip Grey Egerton, Mr. Bowerbank, and Mr. Sowerby. An outline, taken principally from Sir P. G. Egerton's specimen, on a scale of one fifth of the original dimensions, is inserted in the plate at fig. 3. Mr. Sowerby has also a specimen, from the same place, of a species nearly agreeing with this one, but probably distinct: it is much larger; and its system of inner whorls is free from radii and undulations.

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* In the list at p. 128, this fossil is erroneously called *Hamites*; perfect specimens not having been found, when that page was printed.

PLATE XV. a.

Siphonia pyriformis. (Goldfuss, Petrefactenkunde, tab. vi. fig. 7.) This plate represents several varieties in the form of this Siphonia, with some details of its structure; from which it may be inferred that the upper, enlarged part becomes broader in proportion, and more pear-shaped, as it increases in size. But although this may be stated as a general rule, the exceptions are numerous, and there seems to be as much variety in the form of the full-grown specimens of the fossil, as in that of the fruit from which this species has been named.

Figure 4, a specimen nearly entire, shows the root-shaped, lower, part of the stem, by which it was fixed to the rock on which it grew. The condition of the fossil does not enable us to speak decidedly as to the original state of the external surface in the living animal: we can perceive, however, that beneath the surface was a system of large tubular canals, placed in a circle, with some degree of regularity as to their distance from each other, and succeeded at intervals by other concentric circles of similar tubes. These are shown in the vertical and horizontal sections fig. 6. and 7., which had been very carefully ground down by the late Mr. Miller, for the purpose of showing the structure, and in the broken and abraded specimens, fig. 4. and 5. Fig. 8. is a specimen of a lower portion of the stem which belonged to the late Mr. Goodhall, F.G.S. Its external surface having been removed, the tubes which form the lower part of the stem are well displayed: and a similar observation may be applied to the head, fig. 5.

In fig. 9. a head is represented, the greater part of which is embraced by a Serpula. From this tube being at present nearly half immersed in the substance of the head, and from the groove-like impression visible in some places, it would appear that after the Serpula had attached itself, the head must have increased considerably in diameter; still, however, preserving its general form and proportions, where not covered by that tube.

PLATE XVI.

Fig. 1. *Pollicipes lævis*: from Blackdown, Devonshire. Supposed to be of the same species as Plate XI. fig. 5, found in the Gault near Folkstone.

Fig. 2. *Serpula filiformis.* The mode of grouping in this Serpula is remarkable. It consists of smooth, round tubes, slightly curved, and aggregated into elongated, often branching masses. The tubes are rather thick, nearly equal throughout their substance. This fossil may be the same with that which Goldfuss calls *S. socialis*, (Petrefactenkunde, tab. lxix. fig. 12.); but as he identifies the species from the oolite with that of the green-sand, I would retain his name for the former only. The substance of this shell in our green-sand fossil is thinner, and the tube generally more curved, than in the *S. socialis* of the oolite.

Fig. 3. *Serpula Tuba.* Simple, almost solitary tubes, of nearly uniform diameter throughout; shell thin.

Fig. 4. *Serpula Vermes.* The tube gradually increases in size, and has a carina along its upper surface. It is a larger, coarser species than Serpula *carinella*, (Min. Conch. t. 598. fig. 2.). *S. conformis* of Goldfuss (Petrefact. tab. lxvii. fig. 13.) is like it, but has subangular sides.

Fig. 5. *Panopæa ovalis.* The regularly oval form shown by the lines of growth, distinguish this from the species found either in the crag or recent: neither does the anterior side gape so much as in any of them. It is moderately convex and smooth; the beaks are nearest the anterior side, which is closed; the posterior extremity is rounded and gaping.

Fig. 6. *Mya læviuscula.* So perfect is this cast in calcedony, that even the asperities of the epidermis, such as occur in recent species, are preserved. The shell, which is nearly twice as

wide as it is long, is moderately gibbose, and has a characteristic depression along its middle. The sides gape slightly.

Fig. 7. *Amphidesma? tenuistriatum.* A transversely elongated, oblong, very flat shell, with numerous impressed striæ, the posterior extremity slightly truncated; the beaks nearly central, not produced. The genus is rather doubtful.

Fig. 8. *Corbula truncata.* Very similar to one, or two, species in the London clay. Its form is oblong-ovate; the posterior side is produced, obliquely truncated, and pointed towards the front. The surface is transversely striated.

Fig. 9. *Mactra? angulata.* Smooth, subtriangular; the posterior side defined by a ridge; beaks small, nearly close; hinge unknown.

Fig. 10. *Petricola nuciformis.* Suborbicular; striated longitudinally; the edge serrated; the beaks small, sunk into the shell.

Fig. 11. *Petricola canaliculata.* Orbicular, very convex, longitudinally furrowed; furrows nearly covered over edge granulated. The concealed furrows are represented in the magnified section; the edges of the costæ between them are sometimes connected across the furrows.

Fig. 12. *Psammobia? gracilis.* Much elongated transversely, nearly cylindrical; surface marked with many raised lines, which are most elevated at their extremities; posterior side defined, produced, and pointed.

Fig. 13. *Lucina? orbicularis.* Orbicular; convex; longitudinally striated; striæ numerous, often forked; beaks small, distant; edge entire.

Fig. 14. *Lucina Pisum.* Nearly globose; fifteen, or more, reflected ridges cross the surface.

Fig. 15. *Astarte concinna.* Oblong, convex, concentrically furrowed, thick; lunette elongated, deeply sunk; beaks oblique. In everything, except the elongated form, this resembles *Astarte striata,* (Min. Conch. t. 520. f. 1.), which is orbicular.

Fig. 16. *Astarte formosa.* Orbicular, approaching to triangular, rather flat, with thick edges; about ten prominent reflected ridges on the surface; lunette elongated, concave. Found in great numbers at Blackdown.

Fig. 17. *Astarte multistriata.* Very convex; rather wedge-shaped; with many concentric ridges, and numerous fine longitudinal striæ between them; lunette large and broad. A small, rare species.

Fig. 18. *Astarte impolita.* Obovate, convex, rather angular at the beaks: surface antiquated; ligament imbedded in a lanceolate groove.

Fig. 19. *Cyprina cuneata.* Cordato-cuneiform; surface even; posterior side straight, a little produced at its extremity; beaks prominent; valves deep; shell rather thin. The specimens found at Blackdown are seldom larger than the small figure: the large one was in the collection of the late Mr. Goodhall.

PLATE XVII.

Fig. 1. *Cyprina rostrata.* Distinguished by its general form from *Cyprina* (*Venus*) *angulata* (Min. Conch. t. 65.), which it nearly resembles. It is less convex, the posterior extremity is more produced, and the line thence to the beak straighter.

Fig. 2. *Cytheræa subrotunda.* Flat, lenticular, nearly orbicular, smooth; lunette elongated; fulcrum arched. One specimen has an Exogyra adhering to an eroded part of the surface.

Fig. 3. *Venus? truncata.* Rather less convex than *V. lineolata* (Min. Conch. t. 20.); strongly marked with lines of growth; the posterior side expanded and truncated; lunette obscure, lanceolate.

Fig. 4. *Venus? submersa.* Nearly orbicular; valves tumid; the posterior extremity truncated; lunette obscure; hinge-slope rather straight.

Fig. 5. *Venus? sublævis.* Very flat, elliptical, smooth; lunette undefined, not sunk.

Fig. 6. *Venus? immersa.* Very flat, ovate, smooth; lunette deeply sunk; its edge not defined.

Fig. 7. *Cucullæa formosa.* More deeply striated than *C. fibrosa*; and in form resembling *C. carinata* (Min. Conch. t. 207.). Very convex, transversely elongated; posterior extremity pointed.

Fig. 8. *Arca rotundata.* Surface longitudinally striated; the sides unequal; both rounded. There is no space between the beaks.

Fig. 9. *Nucula lineata.* Elliptical; posterior extremity slightly truncated, with a short point at its upper angle; surface transversely striated, with lines straighter than the lines of growth, which they consequently cross twice.

Fig. 10. *Nucula apiculata.* Convex, smooth, transversely obovate; posterior extremity pointed.

Fig. 11. *Nucula obtusa.* Convex, smooth, elliptical; lunette prominent, elongated.

Fig. 12. *Trigonia quadrata.* Nearly square, flat; anterior extremity rounded; concentrically ribbed; each rib bent at a right angle in the middle, where there is an obtuse knob.

Fig. 13. *Modiola reversa.* Transversely elongated, rather flattened; the posterior portion expanded; surface ornamented with thin concentric ridges, which are bent back or reversed upon the shell. In some individuals they are worn away.

Fig. 14. *Mytilus tridens.* The hinge is furnished with three unequal teeth; elongated, convex, carinated; beaks pointed; the surface very smooth. The teeth distinguish this species from *M. edentulus* (Min. Conch. t. 439. fig. 1.).

Fig. 15. *Mytilus prælongus.* Hinge without teeth; shell very thick, much elongated, keel-shaped. It approaches to *M. lanceolatus* (Min. Conch. t. 439. fig. 2.); but, independently of its remarkable thickness, the sides are nearly parallel, as far as the termination of the hinge-line, which is marked by an angle.

Fig. 16. *Mytilus inæquivalvis.* Shell broad; one valve much flatter than the other; both smooth.

Fig. 17. *Perna rostrata.* Ovate, nearly flat; the surface very smooth; the lesser wing produced; the shell thin, contracted at its base. Fragments of this species are very common at Blackdown, but perfect specimens rare.

Fig. 18. *Avicula anomala.* Obliquely elongated, imperfectly five-angled, flat along the middle; many longitudinal, narrow, elevated ridges extend over the surface, and are crossed by fine lines of growth. The valves are very deep, together measuring about $1\frac{1}{2}$ inch, with a square section; length three inches. This shell I believe to be an *Avicula*, although the hinge is not visible.

Fig. 19. *Pecten Millerii.* Oblong, rather convex; radii smooth, sharp, numerous, especially towards the edge; close together. The two smaller figures represent an unusually convex specimen.

Fig. 20. *Pecten compositus.* Oblong; with about 20 smooth, sharp, radii, and two rows of scales between each of them.

Fig. 21. *Lima? subovalis.* Rather quadrangular, elongated; radii very numerous, equal to the furrows between them, and ornamented with one row of rather obtuse distant scales.

PLATE XVIII.

Fig. 1. *Pecten Stutchburiensis.* Suborbicular, compressed; radii more than 60, alternately smaller, scaly; those towards one side large and distant, with oblique striæ between them.

Fig. 2. *Terebratula dilatata.* Wider than long, depressed, imperfectly three-lobed; plaited, plaits about 50, sharp; central lobe elevated; beak of the larger valve short and large. This resembles *Terebratula Vespertilio* of Brocchi, but is not so wide nor so distinctly three-lobed.

Fig. 3. *Terebratula megatrema?.* Moderately convex, transversely obovate; with a few distinct ribs. The beak is large and produced, with a very large perforation: whence the name.

Fig. 4. *Dentalium medium.* (An inferior figure is in Min. Conch. t. 79.) Subulate, very slightly curved, striated; striæ sharp, elevated, alternately smaller, gradually disappearing towards the aperture.

Fig. 5. *Litorina pungens.* Conical, acute, smooth; whorls five or six, the last inflated; aperture orbicular, with a projecting angle above; columella slightly compressed. This species, probably, belongs to a group of shells which Lamarck has called Ampullaria; and which in the Mineral Conchology is referred to Natica, but in the Index to that work is named Globulus. The columella is, however, rather different.

Fig. 6. *Natica canaliculata.* Species the same as Pl. XI. fig. 12, but a much larger specimen.

Fig. 7. *Natica granosa.* Subglobose; spire prominent, pointed, small; covered with spiral ridges which are divided by the lines of growth into rounded granules; whorls very convex; aperture oblong, expanded; umbilicus open.

Fig. 8. *Natica? carinata.* Oblong, with a small distinct spire; surface marked with five prominent rugged keels; aperture large. This shell appears to be umbilicated, but is not perfect; hence the genus is doubtful.

Fig. 9. *Tornatella affinis.* Ovate, pointed; base truncated; surface grooved, grooves crossed by lines; columella with one simple and one double fold. Very like *Acteon* (*Tornatella*) *simulatus* of the London clay, (Min. Conch. tab. 163. fig. 5. to 8.) but more elongated, more acute, and smaller; yet shorter than *Tornatella elongata*, (tab. 11. fig. 1.).

Fig. 10. *Vermetus concavus.* (Min. Conch. t. 57. fig. 1. to 5.) Tube rounded, curved into a depressed spiral, which is concave beneath; the whorls united by an expansion of the shell from the sides. These figures show the prolongation of the tube beyond the spiral part, which is not shown in the Mineral Conchology.

Fig. 11. *Scalaria pulchra.* An acute shell, with blunt costæ; whorls ten, close: a band connecting the costæ passes along the bases of the whorls.

Fig. 12. *Littorina gracilis.* A pretty, elongated, acute shell, with round whorls, bearing decussated furrows on their upper parts; aperture round, with an angle at the base.

Fig. 13. *Phasianella pusilla.* Elliptical, elongated, pointed, perfectly smooth; aperture elliptical, more than half as long as the shell.

Fig. 14. *Phasianella formosa.* Elliptical, elongated, rather blunt; smooth, except a few striæ at the base; aperture more than half the length of the shell.

Fig. 15. *Phasianella striata.* Elliptical, pointed, strongly striated; aperture oval, above half the length of the shell. This is like *Phasianella princeps* (Defrance), but more regularly oval.

Fig. 16. *Fusus rigidus.* Fusiform, costated, transversely striated; costæ rounded, roughened by the lines of growth; transverse striæ prominent, about 10 upon each whorl; whorls five or six, swelled in the middle, compressed at the upper part; aperture more than half as long as the shell, elliptical, pointed at both ends; beak variously elongated. The individuals of this species differ much in length and asperity; the edge of the aperture is frequently reflected.

Fig. 17. *Fusus quadratus.* (*Murex quadratus*, Min. Conch. t. 410, young.) Fusiform, rhomboidal, with a short conical spire, transversely striated and obscurely bicarinated; base produced, conical; whorls about five; aperture sub-rhomboidal. The form of the shell is fully developed in the specimen here represented.

Fig. 18. *Fusus rusticus.* A short, rugged, ovato-rhomboidal shell; with 10 or 12 ribs, each of which is formed into two knobs, so arranged as to give a squareness to the whorls; transversely striated; aperture ovate.

Fig. 19. *Fusus clathratus.* Sub-pyriform, costated and transversely striated; four carinæ crossing the costæ divide the surface of each whorl into three rows of cells; spire very short. The form is nearly that of a Pyrula.

Fig. 20. *Pyrula depressa.* Pyriform, with the spire sunk beneath the surface of the last whorl. Ornamented with many transverse, thread-shaped ridges.

Fig. 21. *Pyrula Brightii.* Ovate, sub-rhomboidal, ventricose, transversely bicarinated, and coarsely striated: aperture sub-rhomboidal; whorls four or five. Some specimens resemble *Fusus quadratus*, (fig. 17.); but they are shorter, have fewer and more thread-like striæ, and crenated carinæ.—Named after Richard Bright, Esq. of Ham Green, near Bristol.

Fig. 22. *Rostellaria retusa.* A short, ovate, striated shell; whorls rounded, with one distinct and one obscure carina on each. It has only one elongated, narrow branch to the lip. The surface between the striæ is particularly smooth.

Fig. 23. *Rostellaria macrostoma.* Turrited, with convex, carinated whorls; carinæ five, the middle one most prominent; aperture small, round, with a very much expanded and flattened lip, furnished with at least two branches besides the curved beak.

Fig. 24. *Rostellaria Parkinsoni.* (Mantell; Geol. of Sussex, t. 18. figs. 1, 2, 4, 5, 6, and 10. Min. Con. t. 558, upper fig. 3.) Turrited, transversely striated, costated; costæ numerous, oblique, long; aperture narrow; its broad lip furnished with one large subulate process directed upwards, and a broad angular expansion below it; beak long and subulate. The specimen, of which two views are here represented, is not perfect, but yet shows the form of the shell better than any before published, and proves that Mr. Parkinson's specimen from Faversham is a different species, although figured as the same in the Min. Conchology.

Fig. 25. *Nassa lineata.* Ovate, acute, wide at the base, transversely striated; whorls flattish, the upper edges sharp, distinct; aperture longer than the spire. Several species from the crag of Suffolk somewhat resemble this; but in them the body whorl is much smaller.

Fig. 26. *Nassa costellata.* Subulate, costated, and transversely striated; whorls about eight, ventricose, each bearing one varix; aperture nearly orbicular; lip thick.

Fig. 27. *Ammonites triserialis.* Discoid, with a flat margin, umbilicate, radiated. Three rows of protuberances, upon the marginal portions of the radii, and about ten tubercles around the umbilicus, distinguish this species. The aperture is nearly square. All its parts are elegantly rounded.

PLATE XXI.*

Fig. 1. *Cypris Valdensis.* (*C. Faba*?, Min. Conch. t. 485.—See the observations on the specific names; supra, p. 177.) Oblong-ovate, convex, punctated; front slightly concave; at one extremity of each valve is a small oval lobe; back hollow between the valves. It is very doubtful whether this be the *Cypris Faba* of Desmarest†, which is the inhabitant of a much newer fresh-water formation than the Wealden, and appears from the figure to be of a somewhat different form. When the figure in the Min. Conch. above referred to, was published, the author was not aware of there being more than one fossil species of Cypris, and supposed that the minute differences

* Plates XIX. and XX, containing representations of *Endogenites erosa*, are described above, p. 172—176.: see also hereafter, p. 349.

† *Bull. de la Soc. Philom.* 1813, p. 259. Pl. IV. No. 8.; *Hist. Nat. des Crustacés Foss.* p. 141. Pl. XI. fig. 8.

which he himself had observed, might have escaped the notice of Desmarest's draughtsman; nor has he yet seen specimens from either of the localities given by that author. Besides the fossil species of Cypris engraved in this plate, we are now acquainted with five others; one in the freshwater formation at Hordwell, (see Lyell in Geol. Trans. vol. iii. p. 288.); one in the coal of Newcastle, (*Cypris arcuata*, Bean *MSS.*); and three found among tertiary marine shells of a modern period, in the island of Java;—though the last possibly may belong to the *Cytherina* of Müller, a genus so near to Cypris, that it may not be distinguishable in the fossil state, and the living species of which inhabit the sea.

Fig. 2. *Cypris tuberculata.* Discovered by the Rev. G. E. Smith at Seabrook near Hythe. Oblong-ovate, convex; with a narrow border to the margin, and from three to twelve tubercles upon the surface. The defined tubercles, and a distinct margin distinguish this species from *C. Faba*; it is also rather broader and flatter; but the general form and the number of the tubercles are variable, as well as the division across the middle of each valve, which in some specimens, as at letter *a.*, is so remarkable, as to indicate a distinct species, or even genus. More perfect specimens, however, shown at *b.* and *c.* are quite free from this division; and intermediate forms have been observed. The specimen represented in the upper figure at *a.* is from Swanage Bay; all the others are from the vicinity of Hythe.

Fig. 3. *Cypris spinigera.* Discovered by Mr. Lonsdale in the Weald-clay of the Isle of Wight. Oblong-ovate, broadest at one end, punctated; furnished with a single, short, conical spine on each valve; by which, and a shorter form, it is distinguished from the other species. It has a narrow lobe at one end of each valve of the same kind as in *C. Faba.* The specimens *a.* are from Sandown Bay; *b.* from Atherfield.

Fig. 4. *Cypris granulosa.* Oblong-ovate, punctated; with prominent granules upon its surface; the lobe at one end observable in *C. Faba* is wanting in this species.

Fig. 5. *Corbula alata.* A rather gibbose, smooth shell, with the posterior side produced and truncated.

Fig. 6. *Psammobia? Tellinoides.* (*Psammobia*, Mantell, Geol. S. E. of England, 251.) Shell transversely oblong-ovate; nearly flat, with conspicuous lines of growth. There are a few longitudinal furrows upon the posterior side.

Fig. 7. *Cyclas parva.* Rather thick, smooth, obovate, approaching lenticular; longer than *Cyclas media.* The larger figure, under letter *a.*, is magnified. The shell is found in great profusion in the Vale of Wardour. In the specimen represented at *b.*, from Dallard's Farm, (*suprà*, p. 259, and also from pits at Dashlet,) the shells are filled with the crusts of a small smooth Cypris.

Fig. 8. *Cyclas subquadrata.* Transversely oblong, with straight sides; strongly marked with lines of growth; flat (perhaps from pressure). Found at St. Leonard's, Sussex.

Fig. 9. *Cyclas elongata.* Transversely elongated, convex, nearly smooth; posterior extremity more or less obliquely truncated: the casts of the outside show that the surface is finely striated concentrically. There are two species of Cyclas in the specimen of slaty clay represented in the upper figure, *a.*, which was found at Etchingham near Robertsbridge in Sussex. The same forms occur also in the ferruginous sandstone of Langton Green, near Tunbridge Wells, with Unio, (see below Pl. XXI. fig. 16.); and in a bed of clay at the top of the cliffs on the west of St. Leonard's. It is probable that the rounder species is *Cyclas parva.* Fig. 9. *b.* is a variety of *C. elongata*, from Hollington near Hastings.

Fig. 10. *Cyclas media.* (Min. Conch. t. 527. fig. 2.) A large specimen; with another showing the hinge and its single tooth under the beak. Transversely obovate, depressed, thick, smooth; anterior side small; posterior rather pointed.

Fig. 11. *Cyclas media*: var. Gibbose; posterior side rather cuneiform and truncated. It has the appearance of being a little distorted by age.

Fig. 12. *Cyclas angulata.* Transversely ovate, convex; posterior side truncated, and separated by an angle and a point. A wider, thinner, more transverse, and larger shell than *C. media.*

Fig. 13. *Cyclas major.* (Cyrena, "larger species," Ann. of Phil. N.S. vol. viii. p. 376, *et passim.*) A convex, smooth shell:—the specimens are generally so imperfect, that their size is almost the only character to be observed.

Fig. 14. *Unio Mantellii.* Dorsal and ventral margins nearly parallel, straight; valves flattened, twice as wide as they are long; anterior side small, rounded.

Fig. 15. *Unio subtruncatus.* Ovate; valves flattish, thick, with obtuse edges: the posterior extremity obliquely wedge-shaped.

Fig. 16. *Unio Gualterii.* Nearly square, with the anterior side rounded; depressed; marked with twice bent parallel rugæ; posterior side somewhat eared. The only fossil species known that shows to any extent the waved rugæ so frequent in the recent species of this genus. The depression in the middle is not constant.

Fig. 17. *Unio Martinii.* Ovate, rather convex, nearly smooth, posterior side pointed; umbones not far from the middle, not prominent.

Fig. 18. *Mytilus Lyellii.* Oblong-ovate, somewhat flattened, especially towards the front; convex towards the pointed beaks.

PLATE XXII.

Fig. 1. *Exogyra bulla.* Oblong, convex, nearly smooth; beaks short, curved. The laterally curved beak distinguishes this shell from the Ostreæ of the same beds. Its shape, however, is very variable.

Fig. 2. *Ostrea distorta.* ("Ostrea; an undescribed species", Ann. of Phil. N.S. vol. viii. p. 376.) Elongated, narrow towards the hinge; one valve flat, both nearly smooth. This and the Exogyra, fig. 1. occur in masses, so closely grouped, that the form of the shells can seldom be traced.

Fig. 3. *Bulla Mantelliana.* (*Bulla*, Mantell, Geol. S.E. of England, 249.) A smooth cylindrical shell, nearly twice as long as wide, truncated at both ends: here accompanied by a small *Paludina*, supposed to be *P. elongata*, but which has a smaller spire than that shell generally has.

Fig. 4. *Melanopsis? tricarinata.* (*Melania tricarinata*, Ann. of Phil. N.S. vol. viii. p. 376.) Subulate, conical; whorls seven, carinated. Three carinæ occupy the exposed portions of the whorls, and are crossed by distinct lines of growth; the central one is the most prominent. More perfect specimens have induced me to remove this from the genus Melania to Melanopsis.

Fig. 5. *Melanopsis? attenuata.* Subulate, elongated; whorls about nine; with several carinæ crossed by undulations, strongest at the upper part of each whorl. The length is in proportion greater, and the whorls more numerous than in the last species, fig. 4.

Fig. 6. *Paludina Sussexiensis.* Spire an elongated cone, with nearly straight sides; whorls five, smooth, more numerous than in either *P. fluviorum*, *lenta*, or *carinifera* of Min. Conch. There are, probably, several other species of Paludina in the Wealden strata.

Fig. 7. *Neritina Fittonii.* (Mantell, Geol. S.E. of England, p. 248.) Convex; tricarinated; aperture large; spire very small. The specimens do not show the aperture, and are hardly sufficient to prove this shell to be a Neritina rather than a Nerita. The lowest figure is magnified.

Fig. 8. *Tornatella Popii.* Elliptical, pointed, smooth; spire small, of about three whorls. The cast shows two plaits upon the columella. Named from the Rev. W. L. Pope, of Tonbridge Wells.

Fig. 12. *Lucina Portlandica.* Orbicular, compressed; surface finely striated concentrically. Very like *Lucina concentrica*, (Annales du Mus. tome vii. p. 238, and tome xii. Pl. XLII. fig. 4. *a. b.*), but much more neatly striated; as shown by the cast of the outer surface, represented in the lower figure, which is from the Isle of Portland. The upper figure is from Swindon.

Fig. 13. *Cytherea rugosa.* Subtriangular; posterior extremity and beaks pointed; valves very convex near the beaks; outer surface concentrically furrowed, furrows most numerous on one side.

Fig. 14. *Trigonia incurva.* (*T. incurva*, Benett, Wiltsh. Fossils, tab. xviii. fig. 2.) Convex, flattened posteriorly, transversely much elongated; surface tuberculated; width more than twice the length. Since this Plate was finished, I have seen specimens from Brill, retaining the shell, which is tuberculated, as in *T. clavellata*, but the tubercles are smaller.

PLATE XXIII.

Fig. 1. *Ostrea falcata.* Elongated, curved towards the posterior side; one valve flat, thick; the other unknown.

Fig. 2. *Nerita angulata.* (*Nerita*, 2nd species; Benett's Catalogue, p. 4.) Subglobose?; with a single carina; spire rather small, obtuse; aperture oblong. This cast shows the muscular impression very distinctly.

Fig. 3. *Natica elegans.* Ovato-rhomboidal, smooth; spire small, pointed; whorls four or five, rather angular, their uppermost edges rounded; aperture more than two thirds of the length. The shell in this specimen, whose form is well preserved in silex, is very thin and smooth.

Fig. 4. *Buccinum naticoïde.* (*Ampullaria elongata*, Benett's Catalogue, p. 2.) Ovate, smooth, thick; spire produced; whorls four or five, their upper edges rounded, the last whorl ventricose; aperture ovate, two thirds the length of the shell; spire longer than in the last species; shell very thick.

Fig. 5. *Buccinum? angulatum.* Fusiform, short; sides of the spire straight; the last whorl has one keel in the middle; aperture rhomboidal, with a short rounded beak. In the produced beak, this specimen approaches to the genus Fusus, but the canal appears to be too broad. The external form has not been seen.

Fig. 6. *Terebra Portlandica.* (*Turritella*, Smith, Strat. Ident. Portland-plate, fig. 2.) Turrited, longitudinally striated; whorls rather concave near the upper edge, where they have also longitudinal furrows; aperture acutely elliptical; beak very short, curved. A very common species in the Portland stone; where, however, the form of the aperture is rarely seen. Here, it is preserved in chalcedony.

Fig. 7. *Serpula variabilis.* A cylindrical, rugose shell; with a considerable portion of the tube unattached, and an irregular suture on one or more sides. When young, the attached portion is triangular.

Fig. 8. *Serpula* triserrata*. A thick, externally triangular, attached tube; with three thin, serrated keels upon the upper angle. Attached to a portion of *Ostrea deltoidea.*

Fig. 9. *Mya depressa*, var. Oval, compressed, smooth, twice as wide as it is long. A much wider specimen than that figured in Min. Conch. t. 418. Intermediate forms are also met with.

Fig. 10. *Exogyra Virgula*; Goldfuss, tab. lxxxvi. fig. 3. (*Gryphæa Virgula*, Defrance.) Much elongated, arched; one valve convex, the other concave or flat; convex valve marked with elevated lines; by which the species is well distinguished.

* This specific name is substituted for "tricristata," given to fig. 8, at p. 231; the latter having been appropriated by Goldfuss to a different species, from the lias near Bantz.—(See Goldfuss, p. 226. tab. lxvii. fig. 6.)

Fig. 11. *Trigonellites latus* Parkinson*. (—*Ichthyosiagones problematicus*, Dr. Rüppell†; *Aptychus lævis*, Von Meyer‡.) Oblong, triangular, compressed; one edge and one angle rounded; the longest edge flattened; one surface concave, striated; the other nearly flat, smooth, but marked with numerous minute circular pits; tissue cellular. I have just learnt from a specimen lent by Mr. Bean, that fig. 18. in Pl. V. of Phillips's Geology of Yorkshire, is a species like this. It is referred by Mr. Phillips to the Oxford clay; but Mr. Bean observes that he has had the same fossil from the Kimmeridge clay of Shotover Hill. A larger species is found at Scarborough, perhaps the same as that before us. (*suprà*, pp. 273, 292, and 316.)

Dr. Fitton, by whom the specimens here represented were found, in clay, near Whitchurch in Buckinghamshire, and at Southrey between Cambridge and Ely, (*suprà*, pp. 273, 292, and 316,) remarks: "When I found this fossil in 1827, I was unacquainted with the publications then "relating to it, and those of Dr. Rüppell and Mr. Von Meyer had not appeared;—but so far as "I can recollect, there was nothing in the circumstances attending these remains that could illus- "trate their origin and connexions. Along with them I found in Buckinghamshire *Gryphæa Vir- "gula*, but no Ammonites: in Cambridgeshire, *Ammonites Lamberti* is mentioned as occurring "at the same place (p. 316.). The valves of the fossil, like those of the Gryphæa, at both places "lay in the clay which contained them, as detached shells might be expected to do, if they had "been lodged confusedly in soft mud. Smaller and thinner valves, perhaps of a different species, "accompanied the larger specimens at Whitchurch, Bucks."

"Of the many names given to this fossil, I have, after some hesitation, retained that of *Tri- "gonellites*, which indicates no more than form; the relations of these singular bodies being still "obscure. As the valves are very often found detached, the term may be used provisionally, or "even ultimately remain, as a convenient denomination; in the same manner as *Belemnites* con- "tinues to be employed, although the bodies to which that appellation is given, are no more than "subordinate portions of some complex structure."

"If the fossils represented in Plate XXIII. be truly of the same species with those of Solen- "hofen, their identity is deserving of notice, geologically."

Fig. 12. *Nerinea Goodhallii.* Turrited, smooth; whorls numerous, half as long as they are wide, concave. There are three plaits in the interior, one upon the columella, one opposite to it, and one above it within the whorl; aperture rhomboidal. The section represented in the left hand figure shows the generic character. The same species but much larger, is found in the Bou-

* "Organic Remains &c.," vol. iii. Plate XIII. fig. 9. and 12.

† *Abbildung und beschreibung einiger neuen oder wenig gekannten Versteinerung, aus den Kalkschiefer Formation von Solenhofen*: von Dr. Ed. Rüppell,—4to, Frankfurt, 1829. Since this sheet has been at the press, (July 1836,) a short paper by Dr. Rüppell has appeared in the London and Edinburgh Philosophical Magazine, (July 1836, vol. ix. p. 32, &c.), to which I wish to refer the reader. Dr. Rüppell regards the two species of Parkinson's *Trigonellites*, as belonging to distinct genera: in one of which (*T. lamellosus*, P.) he supposes the valves to have formed the opercula of an animal somewhat resembling an Ammonite, but destitute of septa: this he proposes to denominate *Pseudammonites*. For the second genus, (to which the specimens represented in Plate XXIII. appear to belong,) Dr. Rüppell retains the name of *Ichthyosiagones*, originally used by Bourdet; and in this case the valves appear to have been internal shells, in large elliptic muscular masses, the structure of which has not yet been brought to light. Subsequently to the publication of Dr. Rüppell's first memoir, Mr. Von Meyer, in a paper referred to below[1], proposed a different view of the relations of these bodies; and gave the name of *Aptychus* to a genus comprehending all the different forms.

[1] *Acta Acad. Leop. Carol. Nat. Cur.* vol. xv. Part II. Read October, 1829; pp. 68—125. tab. lviii. fig. 1, 2, 4.

lonnois; where also other smaller species of this genus occur. This species is named after the late Mr. Goodhall, F.G.S., an indefatigable collector of fossils, and remarkably liberal in affording the use of them to inquirers.

The Wood-cut at p. 129. represents a portion of *Nautilus plicatus*, one third of the original size. The parallel linear furrows which pass over the whorls, are bent three times at acute angles, once on each side and once in the middle, the central angle being directed backwards. There is often some irregularity in the junction of the lines at the angles.

APP. A*.

FIGURES OF VEGETABLE REMAINS.

Sphenopteris gracilis.—The wood-cut at p. 181 represents the impression of a species of fern, discovered in the Hastings-sands, near Tonbridge Wells, by the Rev. W. L. Pope of that place. It has been referred to the genus *Sphenopteris* of Adolphe Brongniart*, notwithstanding its acuminate pinnulæ, and a certain degree of resemblance to *Odontopteris minor*, (Brongn. Veg. Foss. Pl. lxxvii.), on the ground of its apparent affinity to *Sphenopteris Mantelli* (Ibid., p. 170. Pl. xlv. fig. 3—7); its pinnulæ having a midrib, but no lateral veins. This specimen was accompanied by the impression of a species very nearly allied to, and perhaps no more than a variety of, *Sphenopteris Mantelli.*

PLATES XIX. AND XX.

Endogenites erosa.—The description of the plates representing the external form and internal structure of this singular fossil will be found above; (85.) to (89.), p. 172, 176. After those pages had been printed, two remarkable varieties of the form were discovered, in cutting down the cliffs near the White Rock at Hastings; in which the stony nucleus was not only very irregular in figure, but apparently divided into flat lobes, disjoined, or scarcely connected by very thin flakes of stony matter; the whole being externally coated with lignite, which occupied the entire thickness of the fossil in the intervals between the lobes. The form and mode of connexion, or apposition, of these stony nuclei, when divested of their covering, were such as to suggest a comparison with some varieties of Cactus.

PLATE XXII.

All that is known of the Cones and cone-shaped body, Figures 9, 10, and 11, of this plate, is mentioned in the list of fossils, at pages 181, 230, and 290. A section of that represented in fig. 11. on its longer diameter, did not exhibit any indication of vegetable structure: but the general resemblance in the outline and aspect of this specimen to part of the reduced figure of *Zamia horrida* given in Dr. Buckland's plate, (Geol. Trans. 2nd Series, vol. ii. Pl. xlviii. fig. 4.) is, perhaps, deserving of notice.

A *Cone* has recently been found on the shore of the Isle of Portland, not improbably derived from one of the beds of clay, or "Dirt", subordinate to the lower part of the Portland strata, the structure of which, according to Mr. Brown, approaches in some respects to that of *Araucaria.* I am indebted to the kindness of the Rev. David Williams, of Cross, near Bleadon in Somersetshire, to whom it belongs, for an opportunity of submitting this beautiful specimen to the examination of Mr. Brown, who will, I hope, describe its structure in the Transactions of the Linnæan Society.

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* *Prodrome*, &c., p. 50.—*Hist. des Vég. Fossiles*, p. 169.

APP. B.

SYSTEMATIC AND STRATIGRAPHICAL LIST OF FOSSILS.

In the subjoined Tables, the *Genera* of the fossils mentioned in the lists given in the preceding pages, are arranged in systematic order; the *Species* are disposed alphabetically. The new species are in Roman letters; those previously figured, in Italics. The headings of the columns respectively explain their contents; and the following abridgements are employed:—

I.—*Synonyms and References to Authors.*

1. The Roman numerals, followed by Arabic numbers, refer to the Plates annexed to this paper: the small Roman letters refer to the volumes, or Plates, of other publications.
2. *M.C.*—refers to the "Mineral Conchology" of Sowerby; the numbers following those letters denoting the Plates and Figures.
3. *Ben.*—"A Catalogue of the Organic Remains of the County of Wilts". By Miss Ethelred Benett; 4to, Warminster, 1831.
4. *Brong.*—Cuvier and Brongniart's "*Environs de Paris*"; forming the 7th volume of Cuvier's "*Ossemens Fossiles*", 2nd edition.
5. *Ad. Brong.*—Adolphe Brongniart.
   —— —— *Prod.*—"*Prodrome d'une Histoire des Végétaux Fossiles,*" 8vo.
   —— —— *Hist.*—"*Histoire des Végétaux Fossiles,*" 4to.
6. *G.T.*—"Transactions of the Geological Society," 1st and 2nd Series.
7. *Gold.*—Goldfuss, "*Petrifacta Germaniæ, &c.* ("*Petrifacten Deutschlands, &c.*") Folio, Dusseldorf, 1826, &c.
8. *Mant.* or *M.*—refers to the publications of Mr. Mantell, distinguished as follows:—
   Mant. Suss.—"The Fossils of the South Downs"; or "Illustrations of the "Geology of Sussex," 4to, 1822.
   —— *Til.*—"Illustrations of the Geology of Sussex; with figures and "descriptions of the fossils of *Tilgate Forest*"; 4to, 1827.
   —— *Cat.*—"A Tabular Arrangement of the Organic Remains of Sus-"sex," Geol. Trans. 2nd Series, vol. iii. p. 201, &c.; republished in the Geology of the South-east of England.
   —— *S.E. Eng.*—"The Geology of the South East of England," 8vo, 1833.
9. *Mar.*—"Geological Memoir on a part of Western Sussex," by P. I. Martin, London, 4to, 1828.
10. *Nil.*—Nilsson; "*Petrifacta Suecana,*" 1827.
11. *Par.*—denotes the works of Mr. Parkinson.
    —— *O.R.*—"Organic Remains," 3 vols. 4to. 1811.
    —— *Intr.*—"Outlines of Oryctology, or an Introduction to the study of "Organic Remains," 8vo, London, 1822.

II.—*Stratigraphical and Local Distribution.*

In this division of the Tables, the name of the formation is placed at the head of each column; "*Blackdown*" denoting the sands at that place and on the Devonshire coast, which seem to represent the whole of the Green-sand series.

The Lists of Fossils given in the preceding paper are referred to *by Counties*, the names of which are abridged as follows; the numbers after the abridged names denoting the pages where the species, respectively, are mentioned.

1. Kent *or* Kt. .... *Kent*;—(14.) p. 112. 115.; (36.) p. 127, 131.
2. Sur. ..... *Surrey*;—(68.) p. 152, 153.
3. Ham. *or* Hnts.... *Hampshire*;—(75.) p. 156, 159.
4. Suss. *or* Sss. .... *Sussex*;—(90.) p. 176, 181.
5. I. of W..... *Isle of Wight*;—(102.) p. 202, 206.
6. Dor. ..... *Dorsetshire*;—(115.) p. 228, 232.
7. Bl. *or* Dev. .... *Blackdown*, and *Coast of Devonshire*;—(123.) p. 239, 242.
8. S. Wilts, *or* S.W. *South Wiltshire*;—(138.) p. 257, 261.
9. N. Wilts, *or* N.W. *North Wiltshire*;—(142.) p. 267, 269.
10. Oxf. *or* Ox..... *Oxfordshire*; ....
11. Bucks, *or* Bcks.. *Buckinghamshire*; } —(155.) p. 296, 303.
12. Bedf. *or* Bed. .. *Bedfordshire*; ....
13. Cam. ..... *Cambridgeshire*; ..
14. Nor..... *Norfolk*; ..... } —(162.) p. 316, 317.

Fossils.			*Stratigraphical and Local Distribution.*										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
VEGETABLE REMAINS.													
Fucoides.....	*Targionii* ...	Ad. Brong. *Hist.* iv. 6. Man. S. E. Eng. p. 166	.....	I. of W. 203	I. of W. 204.								
Sphenopteris.	*Mantellii* ...	Ad. Brong. *Hist.* xlv. 3-7. Mant. Tilg. p. 55, *note.*	.....	.....	.....	.....	.....	Kent, 171, *note.*					
——— .	gracilis	Wood-cut, p. 181. ...	.....	.....	.....	.....	.....	Suss. 181.					
Endogenites .	*erosa*	XIX. & XX. G. T. 2nd Ser. i. 423. Mant. Tilg. p. 54.	.....	.....	.....	.....	.....	Suss. 164, 167, 168, 172, 181.					
Mantellia ...	*nidiformis* ...	Ad. Brong. *Prod.* 96. *Cycadeoidea megalophylla*, Buckland, G. T. 2nd Ser. vol. ii. Pl. 47, 48.	.....	.....	.....	.....	.....	.....	Dor. 223, 230.				
———	microphylla	*Cycadeoidea microphylla*, Buckland, G. T. 2nd Ser. vol. ii. Pl. 49.....	.....	.....	.....	.....	.....	.....	Dor. 230.				

Besides the foregoing, the following remains of Vegetables have been found; but too indistinct to admit of the determination of their Genera and Species.

Cone, species unknown; XXII. 10.; *Hastings-sand*, Suss. 181.
—— Another unknown species; XXII. 9.; *Purbeck*, Dor. 230.
—— Cone-like body, (*Quæ.* part of a Cycadeous plant); XXII. 11.; *Purbeck*, Bucks, 298.
Wood, coniferous silicified; *Lower green-sand*, Kent, 131, 153., Bedf. 297.; *Weald-clay*, Dor. 228.; *Hastings sand*, Dor. 229.; *Purbeck*, Dor. 221, 230., Oxf. 299.
—— dicotyledonous; *Gault*, Kent, 115.
—— bituminized, *Purbeck*, Oxf. 291.
—— large trunk of lignite; *Purbeck*, Bucks, 299.
Leaves of a Fern?; *Hastings-sand*, Isle of Wight, 203.
——— indistinct impressions of; *Upper green-sand*, Ham. 157.; *Purbeck*, Oxf. 299.

ANIMAL REMAINS.													
POLYPARIA.													
Siphonia.....	*pyriformis* ...	XV. a. Gold. vi. 7.; & xxxv. 10. Park. O. R. ii. p. 96. Pl. 9. & 11.....	.....	.....	.....	Bl. 242.							
———	Websterii ...	G. T. 1 Ser. ii. pl. 27-30 Park. Intr. p. 51-2.	I of W 203										
——— ...	Stems of uncertain species.....	.....	Dor. 228. Bed. 296. Nor. 317†	Nor. 317.	Kent, 130. I. of W. 204. Bucks, 297.	.....	.....	.....	.....	Bucks, 300.			
Cyathophyllum	.....	Gold. p. 54. & 244.	.....	Kent, 113. S. Wilts 258.	Kent, 128								
Lithodendron?	.....	Gold. vol. i. p. 44. *Caryophyllia* (Lam.)	.....	Kent, 113.									
Astrea	*Tisburiensis*	*Madrepora Tisburiensis* (Miss Benett)	.....	.....	.....	.....	.....	.....	.....	S. Wilts 260.			
———	species uncertain	.....	.....	.....	Kent, 128. I. of W. 204.	.....	.....	.....	.....	.....	.....	.....	Cam. 317

† In grey marl, at the bottom of the white chalk, Hunstanton.

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
Madrepora ...	species uncertain	Goldfuss i. p. 22. ...	.....	.....	Kent, 129.								
Turbinolia ...	*Kœnigii*	Mant.Suss.xix.22,24.	.....	Kent, 114. Surrey, 153									
RADIARIA.													
Pentacrinites	*scalaris*?? ...	XI. 2. (*Qu.* Gold. lii. 3. *e.f.*)	.....	Kent, 114. S.Wilts,259	Kent,130								
Echinus? ...	arenosus	XIII. 1.	.....	.....	Kent, 128.								
———	species doubtful	.....	.....	.....	Kent, 128.	Dev. 240.	.....	.....	.....	S.Wilts,260	.....	.....	Cam.317.
Cidaris	*scutiger*	Gold. xlix. 4.	.....	.....	Kent 128.								
———	spines.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cam.317.
Galerites ...	*subuculus*	Gold. xli. 2.....	.....	.....	Kent, 128.								
Clypeus	*cunicularis* ...	Smith; Strata identified	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Dor. 232.
Nucleolites...	*carinatus*	Gold. xliii. 129. f. 11.	.....	.....	Kent, 129.								
Echino-spatangus...	3 new species...	.....	Ham. 156.										
Spatangus ...	*argillaceus*.....	Phil. ii. 4.	.....	Kent, 114.									
——— ...	*Bucardium* ? ...	Gold. xlix. 1.	S.Wilts,258										
——— ...	*Bufo*	Brong. *Env. de Paris*, Pl. V. f. 5. Gold. xlvii. 7.....	.....	.....	.....	Bl. 242.							
——— ...	*granulosus*? ...	Gold. xlv. 3.	S.Wilts,258	.....	.....								
——— ...	*retusus*	Gold. xl. 2.....	.....	.....	Kent, 130.								
———	three species, probably new	.....	.....	.....	Kent, 130.								
——— ...	species doubtful	.....	I.of W.203.	.....	I.of W.204.								
——— ...	new?	.....	.....	.....	.....	Bl. 242.							
CRUSTACEA.													
Cancer?.....	.....	Martin. 34.....	.....	.....	Suss. 157.	.....	.....	.....	.....	S.Wilts,260			
Cypris	granulosa	XXI. 4.	.....	.....	.....	.....	.....	Suss. 177...	S.Wilts.260 ?				
———	spinigera	XXI. 3.	.....	.....	.....	.....	.....	.....					
———	tuberculata.....	XXI. 2.	.....	.....	.....	.....	Kent, 177. I.of W. 205 Dor. 228.						
———	Valdensis ...	XXI. 1. (Olim *C. Faba*)	.....	.....	.....	.....	K.&Sss.177 Sur. 177. I.of W.205. Dor. 228.	K.&Sss.177 Sur.&Ham. 177. I.of W.204.	K.&Sss.177 Sur.&Ham. 177. I.of W.205. S.Wilts 260 Bucks, 297. Dor. 229.				
———	species uncertain	.....	.....	.....	.....	.....	.....	.....	Bucks, 297.				
Astacus	claws	.....	.....	S.Wilts,258	Kent, 128.	.....	.....	.....	.....	S.Wilts,260			
———	(portions of) ...	.....	.....	.....	.....	Dev. 239.	.....	.....	Bucks? 297.				
———	species doubtful	.....	.....	.....	I.of W. 204								

Corystes? ...		Mant. Sx. xxix. 13.		Kent, 113.									
——? ...					Kent, 128.								
—— ...					Suss. 157.								
Annulata.													
Serpula ...	*ampullacea?* ...	M.C. 597, 1—5.				Bl. 242.							
—— ...	*antiquata* ...	M.C. 598, 4.	Kent, 114. Dor. 228.		Kent, 130.	Bl. 242.							
—— ...	*antiquata?* ...				I.of W.204.								
—— ...	*articulata* ...	M.C. 599, 4.		Kent, 114.									
—— ...	*carinella* ...	M.C. 598, 2.				Bl. 242.							
—— ...	filiformis ...	XVI. 2. (Qu. *S. socialis*, Gold. lxix. 12.?)				Bl. 242.							
—— ...	*plexus?* ...	M.C. 598, 1.				Bl. 242.							
—— ...	*rustica* ...	M.C. 599, 3.	Kent, 114.										
—— ...	*tetragona* ...	M.C. 599, 1 and 2.										Bedf. 302.	
—— ...	*tricarinata* † ...	M.C. 608, 3 and 4.										Bucks, 302.	
—— ...	triserrata‡ ...	XXIII. 8.									Dor. 231.	Dor. 231.	
—— ...	tuba ...	XVI. 3.				Bl. 242.							
—— ...	variabilis ...	XXIII §. 7.			Kent, 130.						Dor. 231.		
—— ...	Vermes ...	XVI.4.(Qu.*S.conformis*, Gold. lvii. 13. *b.*)				Bl. 242.							
—— ...	spec. uncertain			S.Wilts,250	Kent, 153.					S.Wilts 261 Oxf., and Bucks, 300.	Oxf., and Bucks, 300.		
——	spec. uncertain				I.of W. 204			Bucks,297.					
Cirripeda.													
Pollicipes ...	lævis ...	XI. 5. XVI. 1.		Kent, 114.		Bl. 241.							
—— ...	radiatus ...	XI. 6.			Kent, 130.								
—— ...	rigidus ...	XI. 6*.		Kent, 114.									
—— ...	unguis ...	XI. 5*.		Kent, 114.									
Conchifera.													
Teredo? ...				Kent, 114. Cam. 114.									
Fistulana ...					Kent, 152.								
Pholas? ...	gigantea ...	XIV. 1.		Kent, 115.	Kent, 130.								
—— ...	*prisca* ...	M.C. 581.			Kent, 130.	Bl. 241.							
Gastrochæna ...					Kent, 128.					N.Wilts268 Oxf. 299....	Bedf. and Bucks,301.		Cam.317
—— ...					I.of W. 204								
Pholadomya ...	*deltoidea* ...	M.C. 197, 4.											Oxf. 303.
—— ...		Martin, Mant. MSS.		Kent, 130.	Suss. 158.								
—— ...	? ...				Kent, 152.								
Panopœa ...	*depressa* ...	XXIII. 9. (*Mya depressa.*)M.C.								Bucks299	S.Wilts 261 Dor. 231....	Dor. 232. Oxf. 302.	
—— ...	*gibbosa* ...	M.C. 42.								Bucks, 299.			
—— ...	ovalis ...	XVI. 5.				Bl. 241.							
—— ...	*plicata* ...	(*Mya plicata*) M.C. 419, 2, 3. Martin, MSS. ...	N.Wlts?267	Kent,114	Kent, 129. Suss. 158. I.of W. 204 Nor. 317.	Dev. 241.							
——? ...	rotundata ...	XIII. 2.			Kent, 129.								

† *S. tricarinata* of Goldfuss, Tab. lxviii. f. 6. is a different species. Sowerby's name and figure (608.) were published in July, 1829.

‡ This specific name is substituted for "tricristata", used at p. 231: see the description, *supra*, p. 347.

§ The Plate is erroneously stated to be XXI. at page 180.

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kim.-clay.	Oxford-oolite.
Panopœa ...	new?	.....	.....	.....	I.of W. 204	.....	.....	.....	.....	.....	.....	.....	.....
——? ...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Bucks 301.	.....	.....
Mya	*depressa*	(See *Panopœa*.)											
——	læviuscula	XVI. 6.	.....	.....	.....	Bl. 241.	.....	.....	.....	.....	.....	.....	.....
——	*mandibula*	M.C. 43.....	N. Wilts267	Iof W203 Dor. 228.	Suss. 158.	Dev. 241.	.....	.....	.....	.....	.....	.....	.....
——	plicata.....	(See *Panopœa*.)											
——	doubtful	.....	.....	.....	Kent, 152.								
——	three species ...	Martin, p. 33.....	.....	.....	Suss. 158.								
Lutraria? ...	*striata*.....	M.C. 534, 1.	.....	.....	.....	Bl. 241.							
——? ...	.....	.....	.....	.....	Kent, 129.								
Mactra	angulata.....	XVI. 9.	.....	.....	.....	Bl. 241.							
Amphidesma	tenuistriatum ...	XVI. 7.	.....	.....	.....	Bl. 239.							
Corbula	alata	XXI. 5.	.....	.....	.....	.....	.....	Suss. 176.	Dor. 229.				
——	*elegans*	M.C. 572, 1.	.....	.....	.....	Bl. 240.							
——	*gigantea*	M.C. 209, 5, 6, & 7.	.....	.....	Ham. 157.	Bl. 240.							
——	*lævigata*	M.C. 209, 1 and 2.	.....	.....	.....	Bl. 240.							
——	*striatula*	M.C. 572, 2. and 3	.....	Kent,113	Ham. 157. Suss. 157. I. of W.204								
——	truncata	XVI. 8.	.....	.....	.....	Bl. 240.							
——?	.....	.....	.....	.....	N.Wilts268	.....	.....	.....	S.Wilts259				
——	(2 other species)	.....	.....	.....	.....	Bl. 240.							
——	new species ...	Martin, p. 32.	.....	.....	Suss. 157.								
Petricola ...	canaliculata	XVI. 11.	.....	.....	.....	Bl. 241.							
—— ...	nuciformis	XVI. 10.	.....	.....	.....	Bl. 241.							
Psammobia? .	gracilis	XVI. 12.	.....	.....	.....	Bl. 242.							
——— .	Tellinoïdes	XXI. 6.	.....	.....	.....	.....	.....	Suss. 178.					
——— .	spec. uncertain	.....	.....	.....	.....	Oxf. 298.							
Tellina	*inæqualis*	M.C. 456, 2.	.....	.....	Suss. 158	Dev. 242. Bl. 242.							
——	*æqualis*	G.T. 2 Ser. iii. p.211.	.....	.....	Suss. 158.								
——	*striatula*	M.C. 456, 1.	.....	.....	.....	Dev. 242. Bl. 242.							
——?	a new species...	.....	.....	.....	Suss. 158.								
Lucina?	orbicularis	XVI. 13.	.....	.....	.....	Bl. 241.							
——	globosa	XI. 2.											
——	pisum	XVI. 14.	.....	.....	.....	Bl. 241.							
——	Portlandica ...	XXII. 12.	.....	.....	.....	.....	.....	.....	.....	S.Wilts 261. N.Wilts268 Bucks, 299.			
——?	a new species...	.....	.....	.....	Ham. 158. Kent, 129.								
——	two species? ...	.....	.....	.....	Suss. 158.								
——	species doubtful	.....	.....	.....	.....	.....	.....	.....	.....	.....	Bucks,301.	.....	.....
Sphæra	*corrugata*	M.C. 335.	.....	.....	Kent, 130. Sur. 153. I.of W. 204								
Astarte	concinna.....	XVI. 15.	.....	.....	.....	Bl. 239.							

——	*cuneata*	M.C. 137, 2.				Bl. 239.				S.Wilts 260 Oxf. 299. Bucks 299.		
——	*elegans*	M.C. 137, 3.										
——	formosa	XVI. 16.				Bl. 239.						
——	impolita	XVI. 18.				Bl. 239.						
——	*lineata*	M.C. 179, 1.				Bl. 239.						
——	multistriata	XVI. 17.				Bl. 240.						
——	*obovata*	M.C. 353.			Kent, 128.							
——	*striata*	M.C. 520, 1.				Bl. 240.						
——	fragments of 3 new species?				Kent, 128.							
——									Bucks, 297.		Dor. 232.	Dor. 232
Cyclas	angulata	XXI. 12.					Suss. 176.		Dor. 229. S.Wilts259			
——	elongata	XXI. 9.						Suss.177.	S.Wilts259 Bucks, 297.			
——	major	XXI. 13.					Sus.176,177 I.of W. 205	I of W205	S.Wilts 259			
——	*media*	XXI. 10. M.C.527,2.					Suss. 176-7 I. of W. 205 Dor. 228.	Suss. 176. I.of W. 205 Dor. 229.	Sus.176Dor 229.SW.259 Bucks, 297.			
——	*media*?							Bucks, 297.				
——	*membranacea*	M.C. 527, 3.					Suss. 177 I.of W. 205 Dev. 228.	Sus. 177.	S.Wilts 259			
——	parva?	XXI. 7.							Bucks, 297. S.Wilts259.			
——	subquadrata	XXI. 8.						Suss. 177				
——	species probably new						I.of W. 205	Suss. 177. Bucks297	Bucks. and Oxf. 297.			
Cyprina	*angulata*	M.C.65, Martin, MS.			Kt128,153? Suss. 157.	Bl. 240. Dev. 240						
——	cuneata	XVI. 19.				Bl. 240.						
——	rostrata	XVII. 1.				Bl. 240.						
Cytherea	*caperata*	M.C. 518, 1.				Dev. 240. Bl. 240.						
——	*lineolata*	M.C. 20, upper fig.				Bl. 240.						
——	rugosa	XXII. 13.								S.Wilt. 260 N.Wilt.268 Bucks, 299	Bucks301	
——	subrotunda	XXII. 2.				Bl. 240.						
——	*parva*	M.C. 518, 46.		Kent, 113. S.Wilts,258	Suss. 157. Ham. 157.	Bl. 240.				Dor. 230.		
——	*plana*	M.C. 20, lower fig.				Bl. 240. Dev. 240.						
Venus	*angulata*	(See *Cyprina.*)										
——	*caperata*	(See *Cytherea.*)										
—— ?	immersa	XVII. 6.				Bl. 242.						
——	*ovalis*?	M.C. 567, 1, 2.			Kent, 131 Suss. 159							
——	*Faba*	M.C. 567, 3.			Suss.159 Nor. 317	Bl. 242.						
——	*lineolata*	(See *Cytherea.*)										
——	*parva*											
——	*plana*											
——	sublævis	XVII. 5.				Bl. 242.						
—— ?	submersa	XVII. 4.				Dev. 242.						

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kim.-clay.	Oxford-oolite.
Venus?	tenera.....	XI. 7.....	.....	Kent, 114	.....	Bl. 242.							
——?.....	truncata.....	XVII. 3.....	.....	.....	.....								
——	small spec. cast	.....	.....	.....	Kent, 131 Suss. 159								
——	two other casts.	Martin, MSS.....	.....	.....	.....								
——?	.....	.....	I. of W. 203	.....	.....	Bl. 242.						Oxf. 302.	Cam.317
——	two species, probably new) ...	}	.....	.....	.....								
——	.....	.....	.....	.....	.....								
Venericardia	tenuicosta	XI. 7*.	.....	Kent, 114. S.Wilts259.	.....								
Thetis.....	*major*?	M.C. 513, 1-4.	Ham. 157.	.....	K.131,153? Suss. 159. I. of W.205	Dev. 242. Bl. 242.							
——	*minor*	M.C. 513, 5, 6.	.....	.....	S.& H. 159. I. of W 205. N. Wilts 268	Dev. 242. Bl. 242.							
——	new.....	Martin, MSS.....	.....	.....	Suss. 159.								
——	new.....	.....	.....	.....	.....	Dev. 242.							
Pullastra?...	.....	.....	.....	.....	.....	.....	.....	.....	.....	Oxf. and Bcks.300	N.Wilts269	.....	Dor. 232
Cardium? ...	*decussatum*	M.C. 552, 1.	.....	Kent, 113.	.....	.....	.....	.....	S.Wilts259				
—— ...	*dissimile*	M.C. 553, 2.	.....	.....	Kent, 128.	.....	.....	.....	.....	S.Wilts 260 NWilts268 Oxf. 301. Bucks 301.	Oxf. 301. Bucks301		
—— ...	*Hillanum*	M.C. 14, upper fig....	.....	.....	.....	Bl. 240.							
—— ...	*proboscideum* ...	M.C. 156, 1.	.....	.....	.....	Bl. 240.							
—— ...	*striatulum*	M.C. 553, 1.	.....	.....	N.Wilts,268								
—— ...	new species, delicately striated	} Martin, MSS.	.....	.....	Suss. 157.								
—— ...	species doubtful	.....	.....	Kent, 113.									
—— ...	.....	M.C.	I. of W.203										
——? ...	.....	.....	.....	.....	.....	.....	.....	.....	S.Wilts 259				
Isocardia ...	*similis*.....	M.C. 516, 1.	.....	.....	Kent, 129.								
——? ...	.....	.....	.....	.....	.....	Bl. 241.							
—— ...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cam.317
Cucullæa ...	*carinata*	M.C. 207, 1.	.....	.....	.....	Bl. 240.							
—— ...	*costellata*?	M.C. 447, 2.	.....	.....	Kent, 128	Dev. 240.							
—— ...	*decussata*	M.C. 206, 3 and 4...	I.of W. 203	.....	Kent, 128 Suss. 157	Bl. 240.							
—— ...	*fibrosa*	M.C. 207, 2.	.....	.....	.....	Bl. 240. Dev. 240.							
—— ...	formosa	XVII. 7.....	.....	.....	.....	Bl. 240.							
—— ...	*glabra*	M.C. 67.....	I.of W. 203	.....	Kent, 128	Dev. 240.							
—— ...	*glabra*?	.....	.....	.....	Suss. 157.								
—— ...	doubtful	.....	Ham. 156.	.....	Kent, 152.								
—— ...	1 or 2 other spec.	Martin, MSS.....	.....	.....	Suss. 157.								
—— ...	new.....	.....	.....	.....	Kent, 128.	.....	.....	.....	.....	.....	.....	.....	Cam.317
—— ...	.....	.....	.....	.....	N.Wilts268								
—— ...	a small species .	.....	.....	.....	.....	.....	.....	.....	.....	.....	Dor. 231.		

Arca	*carinata*	M.C. 44. lower fig....	Ham. 156.			Bl. 239.							
——	rotundata	XVII. 8.....											
——	spec. uncertain .	.....	.....	.....	N. Wilt268.	.....	.....	.....	.....	Oxf. 299.	.....	.....	Cam.317
Pectunculus .	*sublævis*	M.C. 472, 4.	.....	.....	.....	Bl. 241.							
——————.	*umbonatus*	M.C.472, 3; 156, 2-4	.....	S.Wilts, 259	Kent, 130.	Bl. 241. Dev. 241.							
Nucula	*angulata*	M.C. 476, 5.....	.....	.....	.....	Bl. 241.							
——	*antiquata*	M.C. 475, 4.	.....	.....	Suss. 158.	Bl. 241.							
——	apiculata	XVII. 10.	.....	.....	.....	Bl. 241.							
——	bivirgata.....	XI. 8.	.....	Kent, 113									
——	*impressa*	M.C. 475, 3.	.....	.....	Suss. 158.	Bl. 241.							
——	lineata.....	XVII. 9.	.....	.....	.....	Bl. 241.							
——	obtusa.....	XVII. 11.	.....	.....	.....	Bl. 241.							
——	*ovata*	Mant. Sx. xix. 8.....	.....	Kent, 113.	Kent, 129.								
——	*pectinata*	M.C. 192, 6, 7.	.....	Kent, 113. Cam. 113. Kent 152 S.Wilts 259	.....	Dev. 241.							
——?	*undulata*.....	M.C. 554, 3.	.....	Kent, 114.									
——	.....	.....	.....	Bed. 296.									
Trigonia.....	*affinis*	M.C. 208, 3.	.....	.....	.....	Bl. 242.							
—— ...	*alæformis*	M.C. 215.	.....	S.Wilts 259	Kt. 131 & 153 Ham. & Sus. 159 IofW. 205	Bl. 242. Dev. 242.							
—— ...	*clavellata*	M.C.	.....	.....	Kent, 131.	.....	.....	.....	.....	Oxf. 300.	Dor. 231. N. Wilts 269 Bucks, 301.	Dor. 231.	Dor. 232.
—— ...	*clavellata*?	.....	.....	.....	Ham. and Suss. 159.	.....	.....	.....	.....	.....	.....	.....	Dor. 232.
—— ...	*costata*	M.C. 85.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Dor. 232.
—— ...	—— var.....	(See *elongata*.)											
—— ...	*dædalea*	M.C. 88.....	.....	.....	Suss. 159.	Bl. 242.							
—— ...	*eccentrica*	M.C. 208, 1-2.	.....	.....	.....	Dev. 242.							
—— ...	*elongata*	a variety of *T. costata* M.C. 431.	.....	.....	Kent, 131.								
—— ...	*gibbosa*	M.C. 235-6.	.....	.....	N. Wilts268	.....	.....	.....	.....	Dor. 231. S.Wilts, 261 N. Wilts 268 Oxf. and Bucks, 300.	N.W. 269 Oxf. and Bucks302		
—— ...	—— (var.)	approaching to *T. incurva*	.....	.....	.....	.....	.....	.....	.....	Dor. 231.	Bucks. 302.		
—— ...	incurva	XXII. 14. Benett 18, f. 2.	.....	.....	.....	.....	.....	.....	.....	Dor. 231. S.Wilts, 261 N Wilts, 268 Bucks, 300	Bucks302		
—— ...	*nodosa*.....	M.C. 507, 1.	.....	.....	Kent, 131.								
—— ...	*pennata*	M.C. 237, 6.	.....	.....	.....	Dev. 242.							
—— ...	*Pullus*.....	M.C. 508, 2, 3.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cam.317
—— ...	quadrata.....	XVII. 12.	.....	.....	.....	Bl. 242.							
—— ...	*spectabilis*	M.C. 544.	.....	.....	.....	Bl. 242.							
—— ...	*spinosa*	M.C. 86. Martin, MS.	.....	.....	Kent, I31. Suss. 159.	Dev. 242.							
—— ...	*spinosa* (var.)...	XIII. 3.	.....	.....	Kent, 131.								
—— ...	(new, cast)	.....	.....	.....	Kent, 131.								
——	two or more species, indistinct.	.....	.....	.....	Kent, 153.								

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
Unio	*aduncus**	M.C. 595, 2.					Suss. 178.	Suss. 178.					
—	*antiquus*	M.C. 594, 3-5.					Suss. 178.	Suss. 178.					
—	*compressus*	M.C. 594, 2.					Suss. 178.	Suss. 178.	Dor. 230.				
—	*cordiformis*	M.C. 595. 1...					Suss.178...	Suss. 178.					
—	Gualterii	XXI. 16.					.....	Suss. 179.					
—	Mantellii	XXI. 14.					Suss. 179.	Suss. 179.					
—	Martini	XXI. 17.					Suss. 179.						
—	*porrectus*	M.C. 594, 1.					Suss. 179.	Suss. 179.					
—	subtruncatus	XXI. 15.					.....	Suss. 178.					
—	species not distinct						Dor. 128.	Dor. 229.	Bucks, 298.				
—	large, new						.....	.....	Dor. 230.				
—	some other spec. probably new...						Sur. and Suss. 179.						
Diceras	Lonsdalii	XIII. 4.			N.Wilts,268								
Modiola	*æqualis*	M.C. 210, 2.			Suss. 158.								
—	*alæformis*	M.C. 251.			Kent, 129.								
—	*aspera?*	M.C. 212, 4.			Kent, 129.								
—	bella	XI. 9.		Kent, 113.	Suss. 158.								
—	*bipartita*	M.C. 210, 3-4.			Suss. 158.								Dor. 232
—	depressa?	M.C. 8. 3. upper fig.			I.of W.204								
—	*imbricata*	M.C. 212. 1, 3.			Suss. 158.								
—	lineata	XIV. 2.			Kent, 129.								
—	parallela	M.C. 9.			Kent, 129, and 152.								
—	reversa	XVII. 13.			.....	Bl. 241.							
—?	—— casts				Kent, 129.								
—	new				Suss. 158.								
—	new				.....	.....	I.of W. 205						
—	species doubtful				NWilts.268				S.Wilts,260 Bucks, and Oxf. 297.	S.Wilts,261 Oxf. and Bucks, 299			Cam.317
Lithodomus	new species									Dor. 230.			
—	another species?									Dor.230.			
Mytilus	*edentulus*	Mar. 32.M.C. 439. 1.			Suss. 158.								
—	inæquivalvis	XVII. 16.			.....	Bl. 241.							
—	*lanceolatus*	M.C. 439, 2.			Suss. 158.	Bl. 241.							
—	Lyellii	XXI. 18.			.....	.....	.....	Suss. 178.	Bucks, 298.				
—	prælongus	XVII. 15.			.....	Bl. 241.							
—	tridens	XVII. 14.			.....	Bl. 241.							
—	species not determined ..		Oxf. 296.		N.Wilts.268				Bucks298	S.Wilts,261 Bucks, 299.	Bucks, and Oxf. 301.		
Pinna?	(crassa,) new species ...	not figured.			Kent, 130.								
—	*tetragona*	M.C. 313, 1.			Kent, 130. Suss. 158. I.of W.204	Bl. 241.							
—	a cast				Suss, 158.								
—	new?				I.ofW. 204								

* Unio is, by Lamarck, connected with a feminine adjective; ?? but is considered as masculine by Sowerby; and in Mr. Lea's work "On the genus Unio";—4to, Philadelphia, 1832, pp. 6, 7.

Crenatula ...	speciesindistinct			Bed.? 296.						NWilt, 268. Oxf. and Bucks, 300.	N Wilt, 269. Oxf. and Bucks, 301.	
Perna.....	*quadrata*?	M.C. 490, 2.			I.of W.204.							
——	rostrata	XVII. 17.				Bl. 241.						
Avicula	anomala	XVII. 18.				Bl. 240.						
——	gryphæöides ...	XI. 3.	Ham. 156.									
——	pectinata	XIV. 3.			Kent, 128.							
—— ...	a smooth spec. probably new ...	.....			Kent, 128.							
—— ?...	species not determined.....	Martin, MS.		Bed.296.	Suss. 157. Nor. 317.					Oxf. and Bucks, 301		
Gervillia ...	*acuta*?.....	M.C. 510, 5*			Suss. 157.							
——	*aviculöides* ...	M.C. 511. 1—4..... *Perna*, M.C. 66.....			Kent, 128. Suss. 157. Ham. 157. I.of W. 204	Dev. 240.				Oxf. 299...		Dor. 132.	Dor.232. Cam.317.
——	*solenöides*	M.C. 510, 1-4.....			Suss. 157. I.of W.204.	Bl. 240.						
—— ...	species not determined	.....			Kt.128,152 Suss. 157.							
Inoceramus..	*Cripsii*.....	Mant. Suss. 27, 11...		Kent, 113. Cam. 317.								
—— ...	*concentricus*	M.C. 305.		Kent, 113. Kent, 152. S.Wilt. 258 Cam. 317. Nor. 317 †	I. of W 204. ...	Dev. 241.						
—— ...	*gryphæöides* ...	M.C. 584,1. Mar. 33.			Suss. 157.	Dev. 241.						
—— ...	*latus*	M.C. 582, 1. ..... Mant. Suss. xxvii. 10			Kent, 152.							
—— ...	*sulcatus*	M.C. 306.		Kent, 113. S.Wilt.259. Bed. 296.		Dev. 241.						
—— ...	*tenuis*	Mant. Suss. p.132....			I. of W.191							
——	species not determined	.....	S.Wilts 258 Oxf. 296.	Nor. 317†	Suss.? 157							
Lima	semisulcata...	XI. 10. ..... *Plagiostoma semisulcatum*, Nilsson, ix. 3.			Kent, I29. Suss. 158.	Bl. 241.						
—— ?	subovalis.....	XVII. 21.				Bl. 241.						
Plagiostoma .	*cardiiforme* ...	M.C. 113, 3.										Cam.
—— ...	*elongatum* ...	M.C. 559, 2. Mant. Suss. 19, 1. *Modiola parallela*. M.C.9, upper r. hand fig.....		Kent, 114. S.Wilt. 259	Kent, 130. I.of W. 204							
—— ...	*Hoperi*?	M.C. 380.	I.of W.203.									
—— ...	*rigidum*	M.C. 314, 1.			N.Wilt, 268.							
—— ...	obliquatum ‡ ...	G.T. 2ndSer.ii.p.319.								Oxf.300.	Oxf. 301. Bucks, 301.	
—— ...	*rusticum*.....	M.C. 381.										
—— ...	a small species	.....			Kent, 152.							Dor.232.
Pecten	*annulatus*	M.C. 542, 1.										Bucks, 302.
——	*arcuatus*.....	M.C. 205, 5, 7.										
——	*asper*.....	M.C. 370, 1.	Ham. 156. Dor. 228.			Bl. 241.						
——	*Beaveri*	M.C. 158.	Ham.157.	Nor. 317†						Dor. 231. S.Wilt. 261. Oxf. 300. Bucks, 300.	Bcks. 301	
——	compositus	XVII. 20.				Bl. 241.						
——	*lamellosus*	M.C. 239.										

* *Gervillia acuta*, of Min. Con. is stated to be "from calcareous sandstone at Collyweston," in the great Oolite.

‡ A new species, named by Mr. Sowerby,—"to be figured in Min. Conch."; from the highest beds of the Brora district.

† In the *red* stratum, (chalk?), at Hunstanton.

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
Pecten	*Lens*	M.C. 205, 2.										Bedf. 302.	
——	Millerii	XVII. 19.				Bl. 241.							
——	*nitidus*	M.C. 394, 1.	Ham. 157.										
——	*obliquus*	M.C. 370, 2.			Kent, 129. Suss. 158. I.of W. 204 N.Wilt,268								
——	*orbicularis*	M.C. 186.	Ham. 157. I.of W.203. Dor.228. S.Wilt, 258	I of W203 S.W. 259.	Kent, 130. Suss. 158.	Bl. 241.				Oxf. 300. Bucks,300.			
——	*quadricostatus*	M.C. 56, 1, 2.	I.of W.203. Dor.228. S.Wilt,258		Suss. 158.	Dev. 241...							
——	*quinquecostatus*	M.C. 56, 3-8.	Ham. 157. Dor. 228.	I of W203	Kent, 130 and 152. N.W. 268	Dev. 241.							
——	——var.	very convex, young?	Dor. 228.										
——	Stutchburianus*	XVIII. 1.				Bl. 241.							
——	*vimineus*	M.C. 543. 1. 2.											Cam.317
——	species indistinct		Ham. 157.			Dev. 241.				N.W. 268.	Dor. 231. Oxf. 301. N.W.269.		
——	new?	Martin; not figured			Suss. 158.								
Plicatula	*inflata*	M.C. 409, 2.	Ham. 157. I.of W.203.										
——	*pectinöides*	M.C. 409, 1.		Kent, 114.	Kent, 130 and 153.								
——	spec. uncertain									Dor. 231. Bucks, 300.			Cam.317
Podopsis	*striatus*	Defrance. *Dianchora striata.* M.C. 80. 1				Bl. 241.							
Gryphæa	*bullata*	M.C. 368.										Bedf. 302.	
——	*canaliculata*	*Chama*, M.C.26,1,p.68	I.of W.203.			Bl. 240.							
——	—— var.	(a broad variety)				Bl. 241.							
——	*Columba*	M.C. 383, 1, 2.	Ham. 156.										
——	*dilatata*	M.C. 149. 1.								Oxf. 299. (Port.sand?)		Bedf. 302. Bucks? 302.	
——	*globosa*	M.C. 392.		Cam. 317. Nor. 317†.									
——	*sinuata*	M.C. 336.	Ham. 156.		Kent, 128 and 152. I.of W.204.								
——	*vesiculosa*	M.C. 369.	Ham. 156. I. of W. 203 Dor. 228. S.Wilt, 258.			Dev. 241.							
——	*vesiculosa?*				I.of W.204.								
——	*Virgula*	(see *Exogyra.*)											
——	spec. uncertain			I.of W. 203									

* Named after Mr. Samuel Stutchbury of the Bristol Institution.

† In the *red* stratum, (chalk?), at Hunstanton.

Exogyra ...	bulla	XXII. 1.....							Dor. 229.					
——— ...	*conica*.....	*Chama conica, recurvata*, and *plicata*, M.C. 26, 2, 3, and 4. *Exogyra* M.C.605,1–3	Dor.228. S.W.258	Kent, 113 and 115. Bed. 296. Cam. 317.	Kent.152 I of W.204	Dev. 240.								
——— ...	——— (var.)...	ridge high and sharp.	.....	.....	.....	Dev. 240.								
——— ...	new.....	near to *Conica*	.....	.....	I of W. 204									
——— ...	*halyotöidea?* ...	*Chama*, M.C. 25.....	.....	.....	.....	Bl. 240.								
——— ...	*lævigata*	M.C. 605, 4.	Dor. 228.	.....	Kent, 128. Kent, 152.	Dev. 240.								
——— ...	*nana*	M.C. 383, 3.	.....	.....	.....	.....	.....	.....	.....	Bucks, 299.	Dor. 231.	Bucks,302.	Dor. 232.	
——— ...	*undata*	M.C. 605, 5-7.....	I.of W.203.	.....	.....	Bl. 240.								
——— ...	*Virgula*	XXIII. 10..... *Gryphæa*, Defrance .	.....	.....	.....	.....	.....	.....	.....	.....	.....	Bucks,302.		
——— ...	species indistinct	.....	.....	.....	.....	.....	Dor. 228...	.....	.....	S.Wilt.260. Bucks,229.	.....	.....		
Ostrea	*carinata*.....	M.C.365.....	.....	.....	Kent, 129. I.of W. 204	Dev. 241.								
———	*deltöidea*.....	M.C. 148.	.....	.....	.....	.....	.....	.....	.....	.....	Dor. 232.	Dor. 232. Oxf. 302. Bcks 302.		
———	——— var...	near to *deltoidea*	.....	.....	.....	.....	.....	.....	.....	.....	.....	Bedf. 302.		
———	distorta	XXII. 2.	.....	.....	.....	.....	.....	.....	Dor. 229. S.Wilts,259	Bucks299	.....	.....		
———	*expansa*	M.C. 238, 1.	.....	.....	.....	.....	.....	.....	Bucks, 298. (Portland stone?)...	S.W. 261. Oxf. and Bcks.299.	.....	.....		
———	falcata.....	XXIII. 1.	.....	.....	.....	.....	.....	.....	.....	S.Wilts, 261 N.Wilts 268	.....	.....		
———	*gregaria*	M.C. 111, 1-3.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cam.317.	
———?	*lævigata*	*Exogyra?* M.C.605,4.	.....	.....	.....	.....	.....	.....	.....	.....	Dor. 231.	Oxf. 302. Bucks, 302.		
———	*læviuscula*	M.C. 488. 1.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Bucks, 302. Bedf. 302.		
———	*macroptera*.....	M.C. 468, 2, 3.	.....	Kent, 114.	Kt. 129. I of W204 I.of W.204.	Dev. 241.								
———	retusa*	XIV. 4.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		
———	*solitaria*	M.C. 468, 1.	.....	.....	.....	.....	.....	.....	.....	.....	Bucks, 301.			
———	*undulata*.....	M.C. 238, 2.	.....	.....	.....	.....	.....	.....	.....	S.Wilts,261	.....	.....		
———	a new species ...	thick-shelled	.....	.....	.....	.....	.....	.....	.....	Oxf. 299. Bucks,299.	.....	.....	Dor. 232.	
———	(plicated)	.....	.....	.....	.....	.....	Dor. 228.	.....	.....	.....	.....	.....		
———	(smooth)	.....	.....	.....	.....	.....	Dor. 228.	.....	.....	.....	.....	.....		
———	(deeply concave)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cam. 317.		
———	different spec. probably new, but indistinct	.....	Dor. 228. S.Wilt, 258	.....	Kent, 129. Dor. 228...	.....	I.of W. 205 Dor. 228...	Suss. 178.	Dor. 229. Oxf. Bks. 297-8.	.....	Bucks. Oxf. 301.	Oxf. 303.		
Anomia	lævigata	XIV. 6.	.....	.....	Kent, 127.									
———	radiata	XIV. 5.	.....	.....	Kent, 128									
———	convexa *?	XIV. 7.	.....	.....	I.of W.338.									
Orbicula	a new species ...	Martin; not figured.	.....	.....	Suss. 158.									
Terebratula .	*biplicata*	M.C. 90, & 437, 2-3.	.....	Kent, 114. Nor. 317 †	Kent, 130. I. of W.205	Bl. 242.								
——— .	convexa	XIV. 12.	.....	.....	Kent, 130.									
——— .	*depressa*	M.C.502,2. Mar.MS.	I. of W.203	.....	Suss. 159.	Bl. 242.								
——— .	dilatata	XVIII. 2.	.....	.....	.....	Bl. 242.								
——— .	*dimidiata*	M.C. 277, 5.	.....	.....	.....	Dev. 242.								
——— .	elegans	XIV. 11.....	.....	.....	Kent, 130.									
——— .	*elongata*	M.C. 435, 1, 2.	.....	.....	Kent, 130.									
——— .	Faba	XIV. 10.....	.....	.....	Kent, 130.									

* The two species thus marked *, have been omitted by mistake in the list at p. 204. *O. retusa* is from Atherfield, I. of Wight:—See p. 338. note.
† In the *red* stratum, (chalk?), at Hunstanton.

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
Terebratula	*Gibbsiana*	M.C. 537, 4.			Kent, 130, and 153. I.of W.205.								
———	*inconstans*	M.C. 277, 3, 4.											Dor. 232
———	*lata*	*T. lata*, M.C. 100: lower fig. (smooth)			Suss. 158.								
———	*latissima*	*latissima*, M.C. Index. *lata*, M.C. 502, 1. (plicated)			Kent, 130. I. of W.205 N.Wilt268.	Bl. 242.							
———	*Lyra*	M.C. 138, 2.				Bl. 242.							
———	megatrema	XVIII. 3.				Bl. 242.							
———	*nuciformis*	M.C. 502, 3.	N.Wilt,268?		Suss. 159. I.of W. 205 N.Wilts268								
———	*oblonga*	M.C. 535, 4-6.			Kent, 130, and 153. N.Wilts268								
———	*ovata**	M.C. 15, 3.		SWilt? 259	Knt. 130† Suss. 158.								
———	parvirostris	XIV. 13.			I.of W 205.								
———	*pectita*	M.C. 138, 1.	Dor. 228.										
———	*Pisum*	M.C. 536, 6, 7.	I.of W. 203			Bl. 242.							
———	prælonga	XIV. 14.			Kent, 130.								
———	quadrata	XIV. 9.			Kent, 130.								
———	*Sella*	M.C. 437, 1.		Kent, 114	Kent, 130. I.of W.205.								
———	*semiglobosa*	M.C. 15, 9.	Oxf. 296.										
———	*striatula*	M.C. 536, 3-5.				Bl. 242.							
———	*sulcata*	Parkinson. G.T. 1st Ser. v. p. 59.		Kent, 114. Cam. 114.									
———	*subundata*	M.C. 15, 7.		Nor. 317†.									
———	Tamarindus	XIV. 8.			Kent, 130.								
———	*tetrahedra*	M.C. 83, 5.											Oxf. 303
———	two or three spec. probably new		I.of W.203.	S.Wilt, 259	Kent,134. Suss. 159.								Dor. 232
Lingula	*ovalis*	M.C. 19, 4.			Kent, 129.								
———?	truncata	XIV. 15.			Kent, 129.								
———	spec. indistinct				I.of W.204.								
Mollusca.													
Dentalium	*cylindricum*	M.C. 79, 2.				Dev. 240.							
———	*decussatum*	M.C. 70, 5.		Kent, 152. S.Wilt,258.									
———	*ellipticum*	M.C. 70, 6. and 7.		Kent, 113. S.Wilt,258.		Bl. 240.							
———	*medium*	XVIII.4. M.C.79,5				Bl. 240.							
———	spec. uncertain			Cam. 317									
Patella	spec. indistinct				Suss. 158.								

* Called *ovalis*, at p. 130.

† In the *red* stratum, at Hunstanton, Norfolk.

Bulla	Mantelliana	XXII. 3.						Suss. 176.				
Planorbis	spec. indistinct								Oxf. and Bucks, 298.			
Limnæa?									Oxf. 298.			
Auricula?	*incrassata*	M.C. 163, 1-3.			Nor. 317.	Bl. 240.						
———	inflata	XI. 11.		Kent, 113. S.Wilts 258								
———	two species probably new	Martin, MSS.			Suss. 157.	Bl. 240.						
Melania	*Hedingtonensis*	M.C. 39, outer fig.										Dor. 232 Oxf.303.
Melanopsis?	attenuata	XXII. 5. *Melania*, Ann. Phil. (1824) viii. 376.					Dor. 228.	Suss. 178.				
———?	tricarinata	XXII. 4. *Melania*, ibid.					Dor. 228.	Suss. 178.				
——— ?									Bucks, 297.			
Paludina	*carinifera*	M.C. 509, 3.						Suss. 178.	Dor. 230.			
———	*elongata*	M.C. 509, 2.					Kent, 161. Sx.167,178 I. of W. 205 Dor. 228.	Suss. 178. I. of W. 205–6 Dor. 229. Bcks? 297	Dor. 230. S.Wilt,260. Bucks, 298.			
———	*fluviorum*	*P.vivipara*, M.C.31,1					Suss. 178. I.of W.191, 201, 206.					
———	*Sussexiensis*	XXII. 6. Mant.						Suss. 178.	Dor. 230.			
———	two or more spe. probably new*							Suss.178	Bucks, 298. S.Wilt.260. Oxf. 199.			
Neritina	*Fittonii*	XXII. 7. Mant.S.E. Eng. 243.						Suss.178				
Nerita?	angulata	XXIII. 2.								N.Wilts268		
———	*sinuosa*	M.C. 217, 2.								S.Wilts, 261		
Natica	canaliculata	XI. 12. XVIII. 6 *Ampullaria*, Mant. Suss. xviii. 11.		Kent 113. Suss. 152.†		Bl. 241.						
———?	carinata	XVIII. 8.				Bl. 241.						
———	elegans	XXIII. 3.								S.Wilts 261 Oxf. 299		
———	granosa	XVIII. 7.				Bl. 241.						
———	species uncertain		S.Wilts 258	S.W. 259	Suss. 158.‡ Ham. 158. I. of W.204 Nor. 317.	Bl. 241.						
Tornatella?	affinis	XVIII. 9.		Kent, 114.		Bl. 242.						
———	elongata	XI. 1.	Kent,106§.									
———	Popii	XXII. 8.						Suss. 178.				
Vermetus	*concavus*	XVIII. 10. M.C.57, 1-5.	Dor. 228.		I.of W. 205 Suss. 159	Dev. 242.						
———	*polygonalis*	M.C. 596, 6.	I.of W. 203	I. of W.203	Kent, 131.	Dev. 242.						
———	*radiatus*	*Planorbis*, M.C.140,5				Bl. 242.						
———	*umbonatus*	*Vermicularia*, M.C. 57, 6, 7.	I.of W. 203 S.Wilts 258 NWilts 268									
———	——— large ?		I.of W. 203									
———	spec.uncertain		Oxf. 296.									
Scalaria	pulchra	XVIII. 11.				Bl. 242.						

* *Paludina* acuminata, in the list of Isle of Wight fossils, p. 205, and Dorsetshire, p. 228, was intended for a species, supposed to be new, but too indistinct for figuring.

† Inserted as an *Ampullaria*, at p. 152.

‡ Parkinson; Org. Rem. iii. pl. vi. f. 2.

§ In chalk-marl; p. 106. note.

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
Solarium ...	conöideum ...	XI.14.M.C.11.*Cirrus plicatus.* M.C.141,3.	I.of W. 203.	Kent, 114. S.Wilt259.	.....	Bl. 242.							
———	ornatum	XI. 13.	I.of W. 203	Kent,114 S.W.259.									
———	granulatum	*Cirrus granulatus,* Mant.Suss. p. 195.	Ham. 157.										
Cirrus.....	*depressus*	M.C. 428, 3.	Dor. 228.										
Trochus (see *Pleurotomaria*)													
Pleurotomaria	*Gibsii*	*Trochus,* M.C. 278,1.		Kent, 114.									
———	*reticulata*	*Trochus,* M.C.272,2.										Oxf. 303.	
———	gigantea*	XIV. 16.....			Kent, 131, 153.					N.Wilt266. Oxf. 300. Bucks,300.			
——— ...	spec. uncertain												
Trochus	*Sedgwickii* ...	M.C. Index ..... *T. reticulatus,*M.C. 272, 2.....	I.of W. 203										Dor.232
———	spec. uncertain		Ham.157.										Dor.232
Litorina ...	*conica*.....	*Turbo,* M.C. 433, 1.			I.of W. 205	Bl. 242.							
——— ...	gracilis	XVIII. 12.				Bl. 241.							
——— ...	*monilifera*	*Turbo,* M.C. 395, 1.			N.Wilt.268	Bl. 242.							
——— ...	*muricata*.....	*Turbo,* M.C. 240, 4.											Cam. 317
——— ...	pungens	XVIII. 5.				Bl. 241.							
——— ...	*rotundata* ...	*Turbo,* M.C. 433, 2. Martin, MSS.....			Suss. 159 I.of W205.	Bl. 242.							
——— ...	spec. uncertain .	*Turbo?*			Suss. 159					S.Wilt.261.			
Turbo.....	(see *Litorina*).												
Monodonta...	new species? ...									Dor. 231.			
Phasianella .	formosa	XVIII. 14.....				Bl. 241.							
——— ...	pusilla.....	XVIII. 13.				Bl. 241.							
——— ...	striata	XVIII. 15.....				Bl. 241.							
Turritella ...	*costata*	M.C. 565, 4.				Bl. 242.							
——— ...	*excavata*.....	*T.concava,* M.C.565. *Cerithium excavatum* Brong., p.399, ix. 10.				Bl . 242....				S.Wilt 260.			
——— ...	*granulata*	M.C.565,1.Mar.M.S.	S.Wilts258?		Suss. 159. Nor. 317.	Bl. 242.							
——— ...	*muricata?*	M.C. 499, 1, 2.											Cam.317
——— ...	spec. uncertain .	Martin, MSS.....		Kent, 114.	Suss. 159.					Dor.230. S.Wilt 261.			
Potamides?...	a new species....	Mantell, MSS.					Suss. 178. I.of W.?206	Suss.178.	Bucks.298.				
Fusus	clathratus	XVIII. 19.....				Bl. 240.							
——	*quadratus* ...	XVIII. 17. *Murex,* M.C. 410. 1.				Bl. 240.							
——	rigidus	XVIII. 16.....				Bl. 240.							
——	rusticus	XVIII. 18.....				Bl. 240.							
——	spec. indistinct	.....				Bl. 240. ...							Cam.317
Pyrula	Brightii	XVIII. 21.....				Bl. 242.							
———	depressa	XVIII. 20.....				Bl. 242.							
——— ?.....	Smithii	XI. 15.		Kent, 114.									

* Called *Trochus* striatus at page 131.—*Pleurotomaria striata,* M.C. 171. f.1. is a fossil of the mountain limestone.

Murex	*Calcar*	M.C. 410, 2.		Kent, 113.		Bl. 241.						
Rostellaria	buccinöides	XI. 17.		Kent, 114.								
———	*calcarata*	M.C. 349, 6-7.		Kent, 114	Suss. 158. I. of W. 204 Nor. 317.	Bl. 242.						
———	*carinata*	XI. 19. Mant. Sx. xix. 10-14.		Kent, 114. Sur. 153. S. Wilts 259								
———	elongata	XI. 16.		Kent, 114.								
———	marginata	XI. 18.		Kent, 114.								
———	macrostoma	XVIII. 23.				Bl. 242.						
———	*Parkinsonii* *	XVIII. 24. M.C. 558, 3. (upper figure.)		Kent, 114.	Suss. 158. I of W 204	Bl. 242.						
———	retusa	XVIII. 22.				Bl. 242.						
———	*doubtful*				Kent, 130.							
———	very like *Pes pelicani*	Mant. MSS.			Suss. 158.							
———	new species					Bl. 242.						
Buccinum	angulatum	XXIII. 5.								N. Wilt 268. Bucks, 299.		
———	Naticöide	XXIII. 4.								S. Wilt, 260. N. Wilt, 268. Bucks, 299.	Bcks. 301.	
Nassa	costellata	XVIII. 26.				Bl. 241.						
———	lineata	XVIII. 25.				Bl. 241.				Dor. 231. S. Wilt, 261 N. Wilt, 268 Oxf. and Bucks, 300.		
Terebra	Portlandica	XXIII. 6.										
Nerinea	Goodhallii	XXIII. 12.										Dor. 232.
Belemnites	*attenuatus*	M.C. 589, 2.		Kent, 113. S. Wilt, 258. Nor. 317.								
———	*fusiformis*	Park. Org. Rem. iii. t. 8, 13.										Dor. 232.
———	*minimus* †	M.C. 589, 1.		Kent, 113. Sus. 152. Nor. 317.								
———	a large species				Kent, 152.							
———	spec. doubtful		I. of W. 203.		Kent, 128.							
Trigonellites	*latus*	Park. O. R. iii. xiii. 9&12 *Ichthyosiagones*, Dr. Rüppell ‡. *Aptychus*, Von Meyer §....									Bucks, 302. Cam. 316, 317.	
———	a smaller spec.	*Qu.* young of *T. latus*									Bucks, 302.	
Ammonites	*auritus*	M.C. 134.		Kent, 112. S. Wilt, 258.		Bl. 239.						
———	*Benettiæ*	M.C. 539.		Kent, 112. S. Wilt, 258.								
———	*Beudantii*	M.C. 549. Brong. 7, 2. 112.		Kent, 112. S. Wilt. 258.								
———	*biplex*	M. C. 293, 1, 2.								Dor. 230. S. Wilt, 260. N. Wilt, 268. Bucks 299. S. Wilt, 260	S. Wilt, 261. N. Wilt, 269 Oxf. 300. Bucks, 300.	Dor. 231. Bucks, 302. Nor. 317.
———	*Brodiæi*	M.C. 351.										
———	*Catillus*	M.C. 564, 2.	Ham. 156.									
———	*cinctus?*	M.C. 564. 1.	I. of W. 202									
———	circularis	XI. 20.		Kent, 112.								Dor. 232.
———	crenatus	XI. 22.		Kent, 112.								

* *R. Parksonii*, of Min. Con. 349, fig. 1 to 5, (since named *R. Sowerbeyi*, in the General Index, at the end of vol. vi.) is a fossil of the London clay.

† This species, according to Mr. J. Phillips, is distinct from *B. Listeri*: the latter being found only in the *red chalk* of the cliffs at Scarborough.—Geol. of Yorkshire Coast, p. 75. (1st Edit.)

‡ Suprà, p. 348:—See also Edinb. and Lond. Phil. Mag. vol. ix. p. 32.

§ *Act. Acad. Cæs. Leop. Carol. Nat. Cur.* vol. xv. Part ii. tab. lviii. et lix.

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
Ammonites...	*cristatus** ...	XI. 23. Brong. 7. 10.	.....	Kent. 112. and 337.									
——— ...	*decipiens*	M.C. 294.	.....	Bedf. 296.									
——— ...	*denarius*	M.C. 540, 1.	.....	.....	.....	Bl. 239.							
——— ...	*dentatus*	M.C. 308, ...	N. Wilts, 267.	Kent, 112. Kent, 152. Nor. 316. S.Wilt,258.	Suss. 157.	Bl. 239.							
——— ...	new	*serratus*, Park. G. T. 1st series, v. 58..... Allied to *dentatus*, M.C. 308.....	.....	S.Wilt,258.	.....	Bl. 239.							
——— ...	*falcatus*	M.C. 579, 1.	.....	.....	.....	Bl. 239.							
——— ...	furcatus	XIV. 17.	.....	.....	Kent, 127. I.ofW. 204					S.Wilt,260. N.Wilt,268. Bucks, 299.	Dor. 231. Oxf. 301. Bucks,301.	Bcks.302.	
——— ...	*giganteus*	M.C. 126.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
——— ...	*Goodhallii*	M.C. 255.	.....	.....	.....	Bl. 239. Dev. 239							
——— ...	*Gulielmi*	M.C. 311.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Bucks, 302.	
——— ...	*hippocastanum* .	M.C. 514, 2.	.....	.....	.....	Dev. 239.							
——— ...	*inflatus*	M.C. 178.	.....	Kent, 112. Cam. 316.									
——— ...	*Lamberti*	M.C. 242, 1-3.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cam. 317
——— ...	*lautus*	M.C. 309.	Oxf. 296†.	Kent, 112 and 152. Cam. 316. S.W. 258.	.....	Bl. 239.							
——— ...	*Mantellii*	M.C. 55.....	I. of W.202										
——— ...	——— (var.)	without tubercles ...	I. of W.203										
——— ...	*minutus*	M.C. 53, 3.....	.....	Kent, 112.									
——— ...	*Monile*	M.C. 117.	S.Wilts257	S.Wilt 258.	Kent, 127.								
——— ...	*mutabilis*	M.C. 405.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Dor. 232.	
——— ...	*Nutfieldiensis*...	M.C. 108.	.....	.....	Kent, 127.								
——— ...	*ornatus*	Park. G.T. 1st ser. v. 57.	.....	Kent, 112.									
——— ...	*pansus*.....	Park. G.T. 1st ser. v. 57. p. 57. 58.....	.....	Kent, 112.	Lower 2. 1.								
——— ...	*planus*.....	Mant. Suss. xxi. 3....	.....	S.Wilts 258									
——— ...	*proboscideus* ...	M.C. 310, 4-5.....	.....	Kent, 112.									
——— ...	*Rhotomagensis*	M.C. 515. Park. G.T. 1st ser.v. p.58	.....	Kent, 112. I.of W. 191 S.Wilt 258.	.....	.....	.....	.....	.....	.....	.....	Bed. 302.	
——— ..	*Selliguinus* ...	M.C.Gen. Ind.vol.vi. *lævigatus*, M.C. 549. *Selliguinus*‡, Brong. p. 394. vii. 1.	Iof W. 203.	Kent, 112, I.of W. 203 S.W.? 258.									
——— ...	*splendens*	M.C. 103.	Ham. 156.	Kent, 112 Sur. 152	.....	Dev. 239.							
——— ...	*subcristatus* ...	(see *A. cristatus*.)											
——— ...	symmetricus ...	XI. 21.	.....	Kent, 112.									
——— ...	triserialis	XVIII. 27.	.....	.....	.....	Bl. 239.							

* Inserted in the list at p. 112, as *A. subscristatus*; which Mr. Sowerby considers as no more than a variety of the same species.—see p. 337.

† In chalk marl.

‡ At p. 203, the synonym of *A. Selliguinus* is erroneously stated to be *A. Beudantii*.—See Min. Conch. vol. vi.; list of corrections.

——— ...	tuberculatus ...	M.C. 310, 1-3.	...	Kt.112,152. S. Wilts.	...	Bl. 239.					
——— ...	*varians* ...	M.C. 176.	I.of W. 203 S Wilts,257 N.Wilts267								
——— ...	——— var. ...	gibbose	...	...	...	Dev. 239.					
——— ...	*varicosus* ...	M.C. 451, 4, 5.	...	Kent, 112. S.Wilts 258 Cam. 316.	...	Bl. 239.					
———	species not determined	...	...	Kent, 152.	Kent, 127 Suss. 157.	Bl.239.	I.of W.205 a fragment.	...	...	Dor. 230. Oxf. 299. Bcks, 299	Dor. 231. S.Wilt.261 Bcks, 301.	N.Wilt269. Bucks, 302.
——— ...	fragment of a very large species	perhaps *Hamites?*	...	...	Kent127. Kent152.							
Scaphites ...	Hillsii	XV. 1. and 2.	...	...	Kent, 128.							
Hamites ...	*armatus* ...	M.C. 168.	...	Kent, 113.								
——— ...	*attenuatus* ...	XII.1-3. M.C.61,4,5.	...	Kent, 113. Kent, 113.								
——— ...	*compressus* ...	M.C. 61, 7, 8.	...	S.Wilt,258.								
——— ...	*elegans* ...	Park. G.T. 1st Series v. p.558.	...	Kent, 113.								
——— ...	*gibbosus* ...	M.C. 62, 4, (right hand figure)	...	Kent, 113.								
——— ...	*Gigas* ...	M.C.593, 2.	...	...	Kent, 128.							
——— ...	*grandis* ...	M.C.593, 1.	...	...								
——— ...	*intermedius* ...	M.C. 62, 2-4.	...	Kent, 113.								
——— ...	*maximus* ...	M.C. 62, 1.	...	Kent, 113.								
——— ...	*nodosus* ...	M.C. 216, 3.	...	Kent, 113.	Kent, 128.							
——— ...	*rotundus?* ...	XII. 1. and 2. M.C. 61, 2, 3.	...	Kent, 113.								
——— ...	spiniger* ...	XII. 4.	...	Kent, 113.								
——— ...	*spinulosus* ...	M.C. 216, 1.	...	...	...							
——— ...	*tenuis* ...	M.C. 61, 1.	...	Kent, 113.		Bl. 241.						
Turrilites ...	*costatus* ...	M.C. 36.	...	...	...							
——— ...	*tuberculatus* ...	M.C. 74.	I.of W. 203			Bl. 242.						
——— ...	spec. uncertain	...	...	...	I.of W. 205							
Nautilus ...	*elegans* ...	M.C. 116.	Ham. 156.	...	Kt.129,152.							
——— ...	*inæqualis* ...	M.C. 40, lower figure	...	...	Kent, 129.	Bl. 241.						
——— ...	plicatus ...	Wood-cut, p. 129.	...	...	Kent, 129.							
——— ...	*radiatus* ...	M.C. 356.	...	...	I.of W. 204							
——— ...	*simplex* ...	M.C. 122.	...	...	Kent, 129.							
——— ...	*undulatus* ...	M.C.40, upper figure	...	...	Kent, 129.							
——— ...	spec. uncertain †	Martin, MSS.	...	...	Suss. 178.							

REMAINS OF VERTEBRATED ANIMALS.

FISHES.											
Asteracanthus	*ornatissimus* ...	Agassiz, MSS.‡	...	...	...	...	...	...	...	...	Oxf.‡
Chimæra ...	*Egertoni* ...	Dr. Buckland, Geol. Soc. Proceed. ii. 206.	...	...	...	...	...	...	...	...	Oxf. 303.
——— ...	*Townsendii* ...	Ibid.	...	...	...	...	...	...	Oxf. 300.		
Hybodus ...	grossiconus ...	Agassiz, MSS.‡ Mant. Tilg. pl. v. 14. and xv. 2.	...	...	...	...	Suss. 180.				
——— ..	acutus ...	Agassiz, MSS.	...	...	...	...	...	...	...	...	Oxf.‡
——— ...	spec.uncertain	Agassiz, MSS. *Silurus*, Mant. Tilg. pl. x. 4. and 6.	...	...	...	...	Suss. 180.	Dor.‡			

* Erroneously named *H. aculeatus*, at p. 113.

† Besides the foregoing species, an imperfect cast of another *Nautilus* was found in the upper green-sand of the Isle of Wight, at Western Lines, which, at p. 203, has been erroneously called *compressus*. The *N. compressus*, of Min. Con., tab. 38, is a fossil of the mountain limestone.

‡ Egerton:—"Catalogue of Fossil Fish in the collections of Lord Cole and Sir Philip Grey Egerton:" 8vo, 1836.

Fossils.			Stratigraphical and Local Distribution.										
Genera.	Species.	References to Plates and Authorities.	Upper Green-sand.	Gault.	Lower Green-sand.	Blackdown.	Weald-clay.	Hastings-sand.	Purbeck.	Portland-stone.	Portland-sand.	Kimmerid. clay.	Oxford-oolite.
Lepidotus ...	*Fittoni*.....	Agas.ii. 30, *a.* and *b.* *Lepisosteus*, Man.Til. v. 4, 15.; x. 2, 3, 4, 15, and 16.....	.....	.....	.....	.....	I. of W. 206.	Suss. 169. Suss. 180.					
——— ...	Mantellii ...	Agass.ii.xxx f.10-15, and xxx. c. ..... *Lepisosteus*, Man.Til	.....	.....	.....	.....	.....	Suss.180*.					
——— ...	*minor*	Agass. vol. ii. xxxiv.	.....	.....	.....	.....	.....	.....	S.Wilt 260.				
Pholidophorus	*ornatus*	Agass.MSS.†,& i.pl.6	.....	.....	.....	.....	.....	.....	S.Wilt 260.				
———	another species	Agass. Feuilleton, Mars, 1836, p. 79.	.....	.....	.....	.....	.....	.....	.....	....	.....	Oxf. 303.	
Psammodus .	*reticulatus*	Agassiz, MSS.†	.....	.....	.....	.....	.....	.....	.....	.....	.....	Oxf.†	
Pycnodus ...	*microdon*.....	Agass. vol. ii. xxxiv. Mant. Tilg. xviii. 26, 27; tab.xxiii.e. 3,4,5.	.....	.....	.....	.....	Suss. 180.	Suss. 180.					
Tetragonolepis	*mastodonteus*	Agassiz, vol.ii. p.216. t.23.e,3-5. Web.G.T. 2d Ser.ii. pl. vi. 5-7...	.....	.....	.....	.....	.....	Suss.‡	Dor.‡				
Indistinct remains of Fishes.§	Teeth, palatal bones, scales, and vertebræ...	Agass. Geol. Soc. Proc. ii. 101.	Ham.156 I. of W. 203.	S.Wilt.259.	.....	.....	I.of W. 206	I.of W.206	Dor.230. Bcks,298.	S.Wilt361. Bucks, 300.	Dor.?301	Dor. 231.	
REPTILES.													
Trionyx	Bakewellii	Mant. S.E. Eng. 225.	.....	.....	.....	.....	.....	Suss. 179.					
Emys	spec. uncertain	ibid.	.....	.....	.....	.....	.....	Suss. 179.					
Chelonia...		ibid.	.....	.....	.....	.....	.....	Suss. 179.					
Turtles ...		ibid.	.....	.....	.....	.....	.....	.....	Dor. 230.				
Crocodile	remains of two or more species	Mant.S.E.Eng.261—394.....	.....	.....	.....	.....	.....	Suss. 179.					
——— ...	teeth	.....	.....	.....	.....	.....	I.of W. 206 Dor. 128.	I. of W. 206					
Megalosaurus	.....	Dr.Buckland,G.T.2d Ser.i. 394, pl.41-44... Mant. S.E. Eng. 260	.....	.....	.....	.....	.....	Suss. 179.					
Phytosaurus	cylindricodon...	Mant. ibid. 292.....	.....	.....	.....	.....	.....	Suss. 179.					
Hylæosaurus	(new genus) ...	Mant. ibid. 316, pl.v.	.....	.....	.....	.....	.....	Suss. 179.					
Plesiosaurus	species uncertain	Mant. ibid. 281-394.	.....	.....	.....	.....	.....	Suss. 179.	.....	.....	.....	Oxf. 303.	
Pterodactylus	.....	Man.Tilg. pl.viii. f.1, 3, 10, 11, 18. S.E. Eng. p.283.....	.....	.....	.....	.....	.....	Suss.					
Iguanodon ...	.....	Mant. Phil. Tr. 1825, p. 177. S.E. Eng. 268-281; 304-316...	.....	.....	Kent, 153‖	.....	Suss. 169, 170,179-80. I.of W.206.	Suss. 179. I.of W.206. Dor. 229.					
Saurians.....	spec.uncertain	fragments of bones, and teeth.....	.....	.....	.....	.....	Dor. 228.	I.of W.206.	Oxf.298.	N.Wilt269. Oxf.301-3 Bucks,303.	.....	Oxf. 303.	
BIRDS.													
Ardea.....	Bones	Mant. S.E. Eng.283. Geol.Soc.Proc.(1835) ii. p. 203.	.....	.....	.....	.....	.....	Suss. 180.					
QUADRUPEDS.													
Hyæna	remains of	.....	Kent, 153¶										

* Agassiz vii. and Mantell. † Egerton's "Catalogue", &c. 1836. ‡ Fragments, in Mr.Cumberland's Collection at Bristol, from Hastings,—Agassiz: also figured by Mr. Webster.

§ Besides the remains above enumerated, M. Agassiz mentions a fish of the *Gault*, presented by Mr. Hailstone to the Geological Society, which is different from any he had previously seen; and new fishes of the *Chalk* and *Green-sand*, communicated by Mrs. Murchison; (*Feuilleton, Mars*, 1836; pp. 79—80.) *Copröid masses*, consisting principally of phosphate of lime, are found, in the *Gault*, at several places;—as at Folkstone, p. 111; Ridge, in the Vale of Wardour, p. 247; West Norfolk, p. 312; in the Lower Boulonnois, p. 111, *note*: in the *Lower green-sand*, near Pulborough, p. 181; Isle of Wight, p. 206: and in the *Kimmeridge-clay*, in Buckinghamshire, p. 303.

‖ *Supra*, p. 132, *note*; and Text, p. 180.

¶ In sandy loam, at the top of the quarries, Bonghton, near Maidstone.

APPENDIX C.

LIST OF HEIGHTS.*

The following list may be useful to those who examine the country described in the preceding paper, by furnishing some points of known elevation, from which it will be more easy to estimate the surrounding altitudes, than if the entire heights above the sea were to be conjectured.

The height of the tides upon the English coast is influenced by so many variable circumstances, that in selecting a zero for a list of heights, some permanent natural or artificial mark, of easy access, is very much to be preferred to the level of the sea, either at high or at low water; the latter, especially, being objectionable, from the greater difficulty of ascertaining it, and from its being frequently concealed. On this point, I am supported by the opinion of Mr. Lubbock, whose publications on Tides give great weight to his authority. In the subjoined lists, therefore, I should have adopted, as the common point of reference, one of the standard marks hereafter mentioned, had not the heights obtained during the Ordnance Survey, and some others mentioned below, been all referred to the level of the sea at low water; while, as the mode in which that point was determined is unknown to me, I have thought it best not to make any change in the original measures, by conjectural reduction.

The Tide-marks on the Thames, in London and its vicinity, which are referred to in legal proceedings, and which form the base line, or "datum", of many of the railroad sections, have been derived from a long series of observations on the depth of water, first made, I believe, at the East India Docks, by Capt. Huddart, and subsequently at the London Docks; from which latter place, marks, corresponding to the average spring tide high-water mark, have been transferred by levelling, to most of the bridges, and to the lock on the Thames, at Teddington above Richmond, which is, at present, the farthest range of the tide. The *time* of high water varies a little, at different points along this interval, but the ultimate heights are supposed to be the same throughout.

In the year 1830, Mr. Lloyd having fixed a standard mark at the Sheerness dockyards, found the mean rise and fall of the spring tides at that place to be 17·6150 feet; and of neap tides

* The exact determination of heights is, by geologists, regarded as of small importance; but the judgment upon this subject is, perhaps, unconsciously influenced by the difficulty which attends it; since if we could measure heights as easily as horizontal distances, it cannot be doubted that the former would be recorded and reasoned upon more frequently. As geology advances, it becomes more and more necessary that none of the elements which enter into the physical history of the globe should be neglected; and it is probable that many important inferences, not at present foreseen, might result from a correct acquaintance with the levels throughout large portions of the earth's surface. Already it has been ascertained in Sweden, that the land has been gradually raised within a few years, by a small but very perceptible quantity; and in all countries, especially those subject to earthquakes, it is a point of great interest to determine whether the relative levels of the sea and land, are truly as permanent as they are supposed to be. In the Survey now in progress in Ireland, and in the operations for a new map of France, the heights are carefully ascertained and inserted on the maps: perhaps it may still be hoped, that some general system will be adopted for connecting the measurement of heights in England with the Ordnance Survey. In the mean time it is satisfactory to find that at the late meeting of the British Association for the Advancement of Science, (August, 1836), a committee was appointed, and a portion of the funds placed at their disposal, (small, it is true, with reference to the object), for the purpose of devising and conducting observations on the relative level of the land and sea upon our coasts.

11·320 feet; his *mark* (called the "*North Standard*"), being 4·0661 feet above the mean level of high water, and 21·6811 feet above that of low water at spring tides. He then ascertained by very careful levelling, the heights above the standard, of several points in the vicinity of the Thames, between Sheerness and London*: whence it appears that what is called the "*Trinity* "*high-water mark*," at the *London Docks*, $\overset{\text{TRINITY H.W. 1800.}}{\wedge}$ ("answering to XXIII. of the indices "marked on the south-west side of the entrance",) is 2·0112 feet below his "North standard," and consequently 19·6699 feet above low-water mark at Sheerness. The last-mentioned quantity, therefore, must be added to the height of any station above the Trinity mark, at the London Docks, in order to obtain the height of the same station above the sea at low-water at Sheerness.

The places in the South-East of England mentioned in the subjoined lists, are grouped in the order of the counties referred to in the preceding pages, beginning on the north. The names are disposed alphabetically. The heights are expressed in feet and decimals of a foot. The authorities and references to them are the following:

1. "*O.*"—An alphabetical list of all the heights ascertained during the progress of the Ordnance Survey, given in the official account of that operation, published in 1811†, calculated from the level of the sea at low water. The places of the stations are mentioned in the Phil. Trans. for 1800, pp. 576 to 583; and in the "Account," above mentioned, pp. 70 to 81.

2. "*C.*"—Bradshaw's maps of the canals and navigable rivers in the midland counties of England, in three parts. The heights are taken from *low water* at Liverpool, (at a point 6 feet 10 inches below the sill of the Old Dock); which point is stated to be 21 feet below the Trinity House *high-water* mark at the London Docks, and consequently 1·331 feet beneath low-water mark, mean spring tides, at Sheerness, according to Mr. Lloyd.

3. "*M.*"—A manuscript list of heights, principally in Cambridgeshire, ascertained by Mr. M'Lauchlan, of the Ordnance Survey, and Mr. Glaisher of Cambridge, and for which I am indebted to the former gentleman. In this list (which is *not* an official document,) the heights are counted from the level of the sea at low water, in Lynn Deeps.

4. "*B.*"—A MS. list of heights above the sea at low water, ascertained by the late Mr. Bevan of Leighton, for which I am indebted to his son, Mr. Bevan of Wellingborough, and to Mr. Matthews of Leighton.

5. "*W.*"—A short list of heights in the Isle of Wight, subjoined to Mr. Webster's letter to Sir H. Englefield. These are chiefly barometrical, and from their being connected with some of the measurements of the Ordnance survey, it is probable that the zero was low-water mark.

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* Phil. Trans. 1831; p. 167 *et seq.* Mr. Lloyd (p. 190,) "concluded his levellings at a "standard mark at the landing-place on the north-east side of the *New London Bridge*;" which "mark was 2·3967 feet below the North Standard mark at Sheerness;" and consequently 0·3855 foot, (= 4·626 inches), below the Trinity mark at the London *Docks*. The mark here referred to is a flat piece of brass, let into a cavity in one of the two large flags or slabs of granite, which form the landing-place at the bottom of the second flight of steps, descending from the footway on the north-east side of the bridge. The upper flight consists of 29 steps; the second, at the foot of which is the mark, of 26; the lowest flight is commonly more or less concealed by the water. The cavity in which the mark is lodged, is about 3 inches square, with rounded angles; and is two feet from the eastern wall or side of the bridge, and 2 feet 8 inches from the southern edge of the stone. The surface of the brass is about half an inch beneath that of the stone, which is itself a few inches below the level of the water at high spring tides.

† "An account of the Trigonometrical Survey, &c. 1800, to 1809; by Lieut.-Col. Mudge, and "Capt. (now Lieut.-Col.) Thomas Colby, R.E."; 4to, 1811, vol. i. p. 299—311. This work refers to the previous publications in the Phil. Trans. for 1795, 1797, 1800, and 1803, and carries on the account of the operations to the end of 1811.

6. "*F.*"—A small number of heights upon the coast of Kent and Sussex ascertained by myself, from observations with excellent barometers and thermometers by the late Mr. Carey. The lower station in these observations was either the shore itself, (the height of the barometer, below or above the spring-tide high or low water marks, being estimated),—or the drawing-room floors of the houses at Sandgate and Hastings, in which I resided, the height of which above the sea was ascertained by a mean of several observations, sometimes checked by comparison with more elevated stations measured directly from the shore, and again from the houses. The variation of the tides at Sandgate was assumed to be the same as at Dover, = 18·30 feet, and at Hastings, = 21·50 feet; which Capt. Beaufort, by whom I have been favoured with these numbers, states to be respectively the mean derived from a series of observations at those places, in 1834 and 1835.

Stations.	Above the sea at Low Water.
	Feet.
Norfolk.	
Denver Sluice, near Downham Market, above the Deeps at *Lynn*	1
Cambridgeshire.	
Aldreth station, between *Haddenham Mills* and *Aldreth*.....O.	122
Balsham Ord. Station .....O.	380
——— Steeple, (top) .....M.	410
Barton Hill, between Madingley and Barton .....M.	175
Brandon Station (Suffolk) .....M.	190
Burwell Steeple, bottom .....M.	96
Cambridge, level of the Cam.....M.	24·50
——— South Chimney of *St. John's College*.....M.	71·25
——— *Observatory*, top of the Dome. M.	123·50
Chapel Bush, Hazlingfield .....M.	220
Cherry Hinton, Chalk-pits .....M.	150
Cottenham Steeple, top .....M.	116
Duxford-Pen, Duxford :—(Dux*worth*, Ord. map).....M.	372
Ely, Water at the Bridge .....M	14
——, ground at Cathedral .....M.	75
——, Top of the Tower .....M.	290
Fulbourn Windmill .....M.	140
Gog Magog clump .....M.	250
———, Telegraph Station .....O.	260
Haddenham Steeple, (bottom) .....M.	133
Hardwick Spire (bottom) .....M.	225
King's Hedges, cross roads in the Roman Way.....M.	55
Linton, Rivey Wood, (top) .....O.	387
Madingley Station .....O.	188
Maggots Mount, obelisk .....M.	152
Newmarket, Four-mile Stable .....M.	180
———, Ordnance Station.....O.	267
Orwell Station .....O.	255

Stations.	Above the sea at Low Water.
	Feet.
Quy-cum-Stow Steeple, (bottom) .....M.	84
Swaffham Bulbeck, Mills .....M.	130
——— *Prior*, Mills .....M.	140
Soham Steeple, (bottom).....M.	62
Stuntney, near Ely .....M.	60
Sutton Steeple (top). The tower is said to be 108 feet high .....M.	174
Thorney Hill, near Ely .....M.	50
Wicken Steeple, (bottom) .....M.	58
Wilburton Steeple, (bottom) .....M.	122
Witcham Steeple, (bottom).....M.	55
Bedfordshire.	
Brogborough House (chimney), near Ledlington .....B.	395
Dunstable; hill above Zouche's farm, east of the town .....O.	850
Grange Mill, Leighton Heath .....B.	386
Hockliffe Church, battlements.....B.	468
Ivinghoe Church, top of spire .....B.	503
Leighton Buzzard churchyard .....B.	300
———, Grand Junction Canal ¼ mile south of the town.....B.	281·75
———, Turnpike between the town and *Wing*..... .....B.	465
——— *Mile Bush*, between *Leighton* and *Soulbury* .....B.	453
———, Canal level from *Stoke-Hammond* Lock, to the three Locks at *Soulbury* .....C.	256·75
Lidlington Mill Hill.....B.	450
Mentmore, ground near the church.....B.	425
Overend Green, east of *Reach*..... ..B.	482
Ridgmont Castle, hill .....B.	420
Shire Ash, on the road between *Hockliffe* and *Woburn* .....B.	544
Toddington, ground near the Church.....B.	515
Totternhoe-Castle hill .....B.	540
Woburn Church, (battlements) .....B.	479

* It will be found that some of the heights mentioned in the text of the preceding paper, differ from those of the lists here subjoined, having been calculated from an estimated *mean level of the sea*, instead of the level at low water. The difference is one half the mean variation of the spring-tides at the respective places mentioned.

Stations.	Above the sea at Low Water.
	Feet.
Northamptonshire.	
Arbury Hill, near Daventry ....O.	804
Hertfordshire.	
Barkway Windmill: top....O.	513
Berkhampstead, general level of the Vale...B.	350
———, adjacent hills, general level ....B.	600
Bridgewater Monument, (gallery) ....B.	811
Burley Hill, near Royston ....O.	342
Great Chishall, (steeple) ....M.	470?
Heydon Hill, Chishall Down ....M.	480?
Kensworth, hill near Dunstable ....O.	904
Lilley hoe, Ord. Station ....O.	664
Rickmansworth, current ....B.	159·75
Royston, Ord. Station ....O.	481
Tharfield Windmill, (Downs)....O.	570
Two-waters, Grand Junction Canal....B.	275·08
Buckinghamshire	
Aylesbury, Grand Junction Canal ....C.	359·17
———, church, top of spire ....B.	425
Great *Billington*, hill near church ....B.	428
Bow Brickhill, Ordnance Station ....O.	683
———, Church battlements ....B.	600
Brill; *Redshill*, north-east of the town, (lower than the church) ....O.	555
Buckingham; level of Canal ....C.	265
Cheddington, church, top of tower ....B.	429
Crawley, North, church battlements.... B.	437
Fenny Stratford, level of canal ....B.	240
———, (to Stoke Hammond lock).C.	249·25
Muswell Hill, Ordnance Station....O.	744
Newport Pagnell, (canal) ....C.	196·25
———, canal near, from *Wolverton* to *Woolston*, by Great Linford...C.	247·75
Quainton, Ordnance Station ....O.	754
Stewkley, ground near the church ....B.	508
Stony Stratford, canal level, from *Thornton Park* ....C.	252·25
Tring, (canal to *Wendover*, summit level) . C.	404·50
Wendover Hill, Ordnance Station ....O.	905
Wingrave, Church, top of tower ....B.	530
Oxfordshire.	
Abington; canal, above the lock at *Horseferry* ....C.	177·59
Banbury, Canal, North of the town ....C.	312·17
———, South of the town ....C.	305·50
Barnwell, canal to *East Chatton* ....C.	288·75
———, at *Uffington Wharf* ....C.	283·75
Caversham Mill, canal....C.	125·25

Stations.	Above the sea at Low Water.
	Feet.
Clifton Hampden, Canal, W. of Oxford ...C.	159·08
Culham, canal south of ....C.	161·25
Junction of the *Thame* and *Isis*, below *Wittenham Wood* ....C.	154·25
River at *Bensington* Ferry ....C.	153·25
River *Isis*, south-west of *Ensham* village...C.	205·25
Evenlode river, west of Oxford ....C.	194·83
Heyford, upper, canal north of the village..C.	254·83
——— south of the village..C.	250
Iffley, canal below the village ....C.	185·69
Lechlade, (Gloucestershire?) ....C.	243·08
Nettlebed, Windmill ....O.	820
Old Nan's Wear, on the *Isis*, south of *Bampton* ....C.	224·34
Oxford, Canal Lock on the south-west of the city ....C.	190
Purley, on the Thames, below *Maple Durham* Lock ....C.	128·34
Sandford, by Nuneham ....C.	177·59
Shotover Hill, top....O.	599
River *Isis*, east of *Stanton-Harcourt* ....C.	206·25
Streatley, (within the course of the Thames across the Chalk), at the Ferry...C.	138·50
Wallingford, canal level, by *North Stoke*, to *Moulsford*....C.	149·34
Wantage, canal at....C.	288·75
Middlesex.	
Cranford, junction of the Paddington and Grand Junction Canals ....C.	251
Hanger Hill....O.	251
King's arbour ....O.	132
Thames river, north of *Wargrave* ....C.	108·75
———, above *Great Marlow* C	94·17
———, near *Maidenhead* ....C.	79·08
———, at *Eton* ....C.	65·59
———, near *Egham* ....C.	52·08
———, at *Laleham*....C.	48·17
———, at *Shepperton*....C.	40·59
———, at *Teddington*, above the Lock ...C.	23·75
———, at *Limehouse* entrance of Regent's Canal (high-water) ....C.	21
Hunton Bridge ....C.	225·59
London; reservoir of the *Royal Society's Standard Barometer* at Somerset House, above "a fixed mark" on Waterloo Bridge*....	83·21
Rickmansworth, canal near to mill ....C.	170·17
Mole River, opposite *Hampton Court*....C.	28·25
Weybridge, Basingstoke Canal ....C.	50
St. Pancras, Regent's Canal ....C.	79·59
Uxbridge, Grand Junction Canal, south of the town ....C.	113·08

* It is very desirable that the "mark" here referred to (from the Register of the Barometer, &c. published periodically in the Phil. Trans.), should be connected with the standard marks on the Thames: its height above the mean level of the sea, is "presumed about 95 feet." Observations of the barometer and thermometer, are taken by one of the officers of the Royal Society twice every day; at 9 A.M. and 3 P.M.

Stations.		Above the sea at Low Water.
		Feet.
Berkshire.		
Kennet and *Avon* canal, above *Hungerford*	C.	326.50
——— at *Kintbury*	C.	300·17
——— west of *Newbury*	C.	257·58
——— south of *Reading*	C.	124·75
Nettlebed Windmill	O	820
Nuffield Common	O.	757
Scutchhamfly Beacon (chalk)	O.	850
The River *Thames*, at *Sonning*, north-west of the village	C.	115·75
Wytham Hill (north-west of Oxford)	O.	576
Whitehorse Hill	O.	893
Wiltshire.		
Beacon Hill	O.	690
Great Bedwin, canal below the village	C.	385·69
Calne, level of canal	C.	227·92
Chippenham	C.	190·08
Clack, canal west of the village	C.	233·08
River *Isis*, north of *Cricklade*	C.	276·58
———, canal near, at *Kempsford*	C.	261·25
———, near *Inglesham* above *Lechlade*	C.	245·42
———, near *Buscot*, below *Lechlade*	C.	233·34
Melksham, junction of the Wilts and Berks with the Kennet and Avon canal	C.	135·42
Vale of Pewsey, canal from *Devizes* to *Wooton Rivers*	C.	429·5
(The canal falls towards Melksham from this level, by 29 locks, 239 feet.)		
——— canal level at *Burbage Wharf*	C.	462·5
Seend, canal north of, (Kimmeridge clay)	C.	190·50
Stanley Abbey, levels of canal	C.	206·25
	C.	191·08
Thames and Severn Canal, north-east of *Cricklade*	C.	268·5
Wilts and Berks Canal, at *Swindon* Wharf, summit level	C.	333·75
———, level near *Shrivenham*	C.	302·34
Westbury Down, Ord. Station, (chalk)	O.	775
Wootton Basset, canal, south of	C.	301·5
Hampshire.		
Butser Hill, near Petersfield	O.	917
Dean Hill	O.	539
Highclere Beacon	O.	900
Inkpen Beacon	O.	1011
Portsdown Hill (top of Nelson's Monument)	O.	447
Itching Navigation, at *S. Stoneham*	C.	16·17
——— at *Bishopstoke*	C.	56·42
——— west of *Twyford*	C.	101·50
Itching Navigation, south-west of *Winchester*	C.	129·58
Stockbridge Hill	O.	620
Andover canal, at *Red-Bridge*	C.	5·83
——— at *Romsey*	C.	61·42
——— at *Stockbridge*		120
——— at *Andover*		184·83
Surrey.		
St. Ann's Hill	O.	240
Bagshot heath	O.	463
Banstead Down, near *Banstead*	O.	576
———, hundred acres (chalk)	O.	443
Botley Hill	O.	880
Croydon Canal, at *Sydenham*	C.	173·17
———, junction with Surrey Canal, *Deptford*	C.	17·42
Hindhead	O.	923
Leith Hill, Tower, (base?)	O.	993
Norwood	O.	389
Surrey and Sussex Canal passing *Wonersh*	C.	128·42
——— *summit level*, from *Rushwood* to *Sidney Wood*	C.	162·75
River *Wey*, at *Godalming*	C.	128·58
——— below Catherine Lock	C.	111·92
Kent.		
St. Alban's Court, near Wingham	F.	119·4
Allington Knoll	O.	329
Copt Point, Gault Cliff	F.	144
Dover, Castle	O.	469
—— mean range of spring tides 1834.	*	18·25
——— 1835	*	18 25
——— by report of Harbour-Master 1828	F.	20·00
——— mean of neap tides do.	F.	13·00
———, *extreme* variation of spring tides	F.	24·00
Folkstone, hill, Ordnance Station	F.	575
———, Turnpike	O.	585
Folkstone, mean difference of spring tides by report of experienced boatmen	F.	18·0
——— of neap tides	F.	11·0
———, top of the *Chalk* cliff, nearest to the town	F.	566
———, *Martello Tower*, No. 1. Base	F.	261
———, Ditto No. 2. Base	F.	193
———, Ditto No. 3. Base	F.	172
———, cliff near the town, on the east	F.	117·60
———, cliff at the Church	F.	145·50
Goudhurst, Kent	O.	497
Greenwich, Observatory	O.	214
High nook, near Dymchurch	O.	28
Hollingburn hill	O.	616
Nail Down, west of Sandgate	F.	334
Paddlesworth, hill	O.	642
Ramsgate, mean range of spring tides; 1834.	*	15·25
——— 1835.	*	14·75

* Capt. Beaufort, R.N. MSS. from the Reports of the Coast Guard Preventive Service Officers.

Stations.	Above the sea at Low Water.
	Feet.
KENT, (*continued.*)	
River Medway, at *Tunbridge* ....C.	79·69
——— at *Brand Bridge*....C.	47·08
——— west of *Yalding* ....C.	41.69
——— south of *Teston*, above the Lock ....C.	33·69
——— south of *Maidstone*, (Lower green-sand) ....C.	21·58
——— north-west of *Allington* Castle ....C.	20·08
Ruckinge church, west of *Aldington* ....O.	37
Saltwood Castle, near Hythe, in the court...F.	217·50
Sandgate, drawing-room floor of a house in Prospect Place ....F.	57·50
———, hill top over Prospect Place....F.	263·50
Shakspeare's Cliff, top....F.	350
Shooter's Hill ....O.	446
South Foreland, Upper Light-House, base..F.	355·20
———, Lower Light-House, base..F.	276·42
Swingfield, steeple-top....O.	530
Tenterden, (steeple)....O.	322
Tolsford Hill ....O.	572
SUSSEX.	
Arun river, at Thorndell, before it enters the Chalk range ....C.	17·58
Beachy Head, highest cliff ....F.	543
———, old signal ....O.	564
———, base of the house.F.	559
———, *Holywell* chalk pit, cliff top.F.	241
Bell-Tout; cliff edge ....F.	297
———, *First Sister*, or "First of the Sevens," (cliff top) ....F.	266·50
Brightling-Down near Battle ....O.	646
Brighton, site of a former signal-house on the race-course....F.	406
Canal, west of *Loxwood*, 11 Locks below the summit level ....C.	75·58
——— near *Spurland* farm, below Mallam Lock ....C.	44·42
——— near *Rowner*, farm ....C.	36·58
——— near *Snape*, below Middle Lock ...C.	25·34
——— near *Neville Wood*, and thence to *Pulborough* ....C.	14·58
Chanctonbury ring, South Downs, (Chalk), Ordnance Station....O.	814
Clayton, range of the chalk on the south, about 200 feet lower than the general height of the ridge ....O.	462
Crowborough-Beacon ....O.	804
Ditchling-Beacon....O.	858
Fairlight Down, top, Ordnance Station ...O.	599
———, same place....F.	593·6
———, floor of the octagon room in Dr. Batty's house....F.	555·7
Firle Beacon, South Downs ....O.	820

Stations.	Above the sea at Low Water.
	Feet.
Frant, near Tunbridge Wells, (top of steeple)....O.	659
Hastings; *Castle hill*, highest point ....F.	271
———, *East cliff*, average level ....F.	257
———, the *Lovers' Seat*....F.	350
———, average range of spring tides 1834....*	22·00
———, Ditto....at a point about 3 miles west of the town; 1835....*	21·00
——— mean of two years....*	21·50
Newhaven, highest point of the Castle hill..F.	208
Ouse River, at *Ryeland Bridge* ....C.	136·69
———, north-west of *Lindfield* ....C.	110·25
———, west of *Sheffield Park* ....C.	67
———, north of *Goldbridge* Lock....C.	54·17
———, *Sharp's lock*, 2 miles west of Uckfield....C.	48·90
———, *Barcombe Mill*, above the locks.C.	26
———, *Hamsey Place*, north of Lewes C.	18.50
Portobello, top of cliff; about the average level of the cliff from *Rottingdean* to *Newhaven*	96·60 to 100
Rooks Hill Beech, near Goodwood; Ordnance Station ....O.	702
Rother River, west of *Midhurst* ....C.	68·58
———, near *Pulborough* ....C.	19·08
Rottingdean, cliff top beneath the Windmill ....F.	128
Seaford Cliff, top, N.E. of the Signal ...F.	309
ISLE OF WIGHT.	
Bembridge Down ....W.	355
Black-gang Chine, guardhouse on the headland ....W.	400
St. Boniface Down ....W.	355
St. Catherine's Lighthouse ....O.	830
——— *Down*, cliff top under the hill ....W.	591
Culver-cliff top... ....W.	259
Mottestone Down....O.	698
Shanklin Down, (*Dunnose* of the Ordnance Survey) ....O.	792
DORSETSHIRE.	
Blackdown hill, (north-east of Abbotsbury).O.	817
Bull-barrow (south of Sturminster) ....O.	927
Charlton, Common (north of Wincanton).O.	582
Corfe Castle hill ....O.	207
Downs over *Handfast Cliff* ....O.	584
Height of the *Cliff* itself ....O	352
Nine Barrow Down (Isle of Purbeck) ...O.	642
Pillesdon hill (west of Beaminster)....O.	934
Wingreen hill (south-west of Berwick St. John) ....O.	941

* Capt. Beaufort, R.N.; MSS. from the Reports of the Coast-Guard Preventive Officers.

7. *Railroad Sections.*—From the uncertainty of the tide levels, and the inherent defects of the methods, both trigonometric and barometrical, by which most of the heights above mentioned were obtained, they cannot be absolutely depended on within a few feet. Those given in the sections of the numerous railroads through England, having been ascertained by levelling, are much more to be relied upon: they are, probably, as accurate as any that ever have been obtained in undertakings not expressly directed to scientific purposes; and are the more valuable, as the two other modes of measurement are most erroneous when the elevations are small. In the course of a few years the entire surface of this country, wherever the introduction of railroads is practicable, will thus be covered with a network of intersecting lines, along every one of which the heights will have been determined to within a few inches of the truth. A well-arranged collection of the levels will then form a very useful compilation to inquirers in various departments of physical science; and it is to be hoped that some person properly qualified, who has leisure for such a purpose, may be induced to enter upon the undertaking*.

The following Lists contain only the approximate height of a small number of points, along the principal lines of railroad in that part of the South-East of England which is represented in the map, Pl. IX. The first two cut through the chalk range of the midland counties, in passing from London;—1. North-westward, as far as Stony Stratford;—2. By Reading, through the defile of the Thames, towards Abington; and thence, westward, to the vicinity of Chippenham. 3. The South-eastern line, after passing the chalk near Godstone, descends the Valley of Kent, by Tonbridge and Ashford, to Folkstone and Dover. 4. and 5. The Brighton lines traverse the chalk downs and the Wealden denudation, southwards, between London and the Sussex coast. 6. The Southampton railroad crosses the continuation of the anticlinal line of the Wealden towards the Vale of Wardour, and connects the basins of London and the Isle of Wight.

I.—HEIGHTS ON PART OF THE LONDON AND BIRMINGHAM RAILWAY†.

Stations.	Height above the Datum.	Stations.	Height above the Datum.
	Feet.		Feet.
The Datum in the Section of this Railroad, is the same with that of Bradshaw's map of canals; viz. *Low-water* mark at the *Old* Docks, *Liverpool*, (6 Ft. 10 In. under the Dock sill.)		Highest point of the ground over the *Tunnel* near *Primrose Hill*, about 0·1 mile north-west of letter *P*	189·50
		Road from London to Edgware, at *Kilburn*	130
		South-east bank of the *Brent*, about a mile east of *Apperton*	87·6
Datum below the Trinity *high* water mark, at the *London Docks*: (Bradshaw)...21 feet.		Road from *Harrow* to *Harrow Weald*, about	
[The datum at Liverpool, therefore, is *beneath* low-water mark at Sheerness, (21 — 16·6699 =) 1·330 feet.]		½ mile beyond *Greenhill*	190
		——— *Stanmore* to *Pinner*, near Dove-house farm	218·08
Height of railway above the datum at the *Regent's Canal* near *Camden Town*	118·75	Highest point of ground over the *Tunnel* at *Oxhey-lane*: north of the *e* in *lane*	287

* In the present unfinished state of the works, the attempt would be premature; but when the railroads have been completed, the several lines will furnish admirable facilities for accurate levelling along them, and for connecting the heights in the interior of England, with fixed and durable standards at well-chosen places on the coast, the height of which above the sea, may be afterwards ascertained by long-continued observation. From the first of these operations, we should obtain the *relative* height of a number of points, any one of which might be taken as a standard, and all of which are, probably, themselves in motion, and may be expected to differ in elevation after the lapse of years. On this account, the multiplication of standard marks, both inland and on the shore, is very desirable; while the latter should be compared, from time to time, with the supposed invariable mean level of the sea. The height of the tides themselves, however, is in some degree affected by the features of the coast, which it is well known to geologists, are in a state of constant and even rapid alteration.

† Where roads, canals, and streams are mentioned in these lists, the points referred to are those of their intersection by the railway. The names of the places are in the Ordnance Maps; and the precise points are indicated by reference to adjacent words, letters, or objects on the map.

Stations.	Height above the Datum.
Birmingham Railroad (*continued*).	Feet.
Railroad at south-east end of Tunnel	236
Bend of the *Brook*, east of *Oxhey-lodge*.....	214·83
Turnpike road from London, near the entrance of *Watford*	200·50
Valley, or flat, of the *Colne*, north-east of *Watford*	189·25
Road from *Watford* to *St. Alban's*, midway between *Callow-land* and *Nascot-farms*...	251·83
Highest point over the Tunnel at *Russel-farm*, near the top of *R* in *Russel*	342
Railroad at entrance of the Tunnel	250
Grand Junction Canal, about ¼ mile south-east of *Nash Mill*.....	249
Canal, about 3 miles from the last place, between *Boxmoor* and *Bourn-end*	297·83
Road to *Berkhampstead Place*, between the Canal and the *Castle*	352
Highest point over the Tunnel, near the *road* from *N. Church* to *Ashridge*; bottom of letter *N* in *Northchurch*	442·42
Highest ground over the railway at *Three-score-acres lane*; east of *a* in *Grand*.....	461·83
Road from *Tring* to *Dunstable* (boundary between Herts and Bucks); about midway between *Folly* and *Bulborne*	446·17
Grand Junction Canal, south-east of *Seabrook*.....	347·75
Road from *Ivinghoe* to *Leighton-Buzzard*; on the south-west of *Horton*; (a continuation of the Vale of Aylesbury)	332·58
Road from *Leighton* to *Wing*, at an elbow east of *Southcot*	318
Railroad at entrance of the Tunnel *Linslade Wood*, north-west of *Leighton*.....	306
Highest point of ground over the Tunnel, about letter *l* in *Linslade*.....	391
Road from *Great Brickhill* to *Soulbury*, near Rislip farm; north of *R* in *Rislip*...	302·75
——————————— to *Newton Longville*	317·69
Stream under the railroad between *Water Eaton* and *Bletchley*, about ¼ mile west of the word *Water*, and south-west of *Stony Stratford*	247
Brook under the main road to *Stony Stratford*, near *Denbigh Hall*; about 46⅛ miles from London	264·42
Average height of railroad, from the Tunnel at *Linslade Wood*, to the road last mentioned .....about	300
Grand Junction Canal, about ¾ mile east of *Wolverton*, north of letter *l* in *Canal*.....	247·75
Bottom of the *Valley* of the *Ouse* and *Tove Rivers*; about 2½ miles north-east of *Stony Stratford*; near *r* in the words *River Ouse*	213

II.—PART OF THE SOUTH-WESTERN RAILROAD; LONDON TO BRISTOL.

The former terminus, or starting point, of this road, was on the Birmingham railway, about a mile west of Kensal Green. The present terminus is at *Westbourn Green*, about ¾ mile north of *Bayswater*, on the Uxbridge road from London.	
The Datum, or base, of the Section is supposed to be about 7 feet above the Trinity high-water mark, at the *London Docks*.	
[Therefore, (approximate) height of the datum, above low-water mark at Sheerness is (19·6699 + 7) = 25·6699 feet.]	
Paddington Canal, at the north-west angle of *Old-oak* Common.....	85
Brent River at *Hanwell*, south of letter *H*...	14
Road from London to *Uxbridge*, near the cross road from *Greenford* to *Norwood* and *Osterley Park*	65
Paddington Canal, east of letter *Y* in *Yedding Brook*	84
Grand Junction Canal, near *Botwell*.....	84
River *Colne*, near W. Drayton; west of the words *Colham Mill*	68
General level of the surface, on the line from near *Southall*, to the heights over the *Valley of the Thames*, east of Maidenhead Bridge .....about	86
Road from *Slough* to *Stoke Poges*; about ¼ mile from the cross roads	90
Cross road from *Amerton Bank* to *Taplow*, about 24½ miles from London, on the road to *Maidenhead*	69
River *Thames*, about ¼ mile south of *Maidenhead Bridge*	56
Highest point of ground over the railroad; north-east of the road from *Shottesbrook* to *Knowle Hill*; about ½ mile north of the letters *ot*	142
River *Lodden*, about a mile south-west of *Ruscombe* church.....	95
Road from London to *Reading*, about 36½ miles; near letter *k* in *Holme Park* (over the Tunnel).....	180
Railroad at the entrance of the Tunnel on the east; south-east of the 36th milestone ...	126
Highest ground over the Tunnel near its western extremity	193
River *Kennet*, near *Broken-brow*, north-west of letter *B*; about ½ mile east of *Reading*	98
General level of the Valley of the Thames, from *Broken-brow* to near *Kentwood*, about.....	100
Highest point of *ground* over the *Tunnel* near Purley; south of east of the words *Purley Hall*.....	253
Road about 4½ miles from Reading to *Pangbourn*, north of *y* in *Purley Hall*	147
Thames River, about ⅛ mile north by east from *Moulsford* Church, Berks	117
Highest ground over the line of railroad, between the Thames and *West End*, on the south-west of *Cholsey Field*.....	195
Paper mill stream, north-east of *South Moreton*; and north-west of *P* in *Paper*	134

Stations.	Height above the Datum.
	Feet.
General level of surface, from the *Thames* near *Moulsford* to *East Hagborne*	152
Road from *Dudcot* to *Appleford*; west of the word *Vauxhall*	173
Road to *Abingdon* and *Oxford*, at the entrance of *Steventon* on the south-east	195
Berks and *Wilts Canal*, about 0·4 mile north-east of *Pinmarsh farm*	191
Brook north of *Grove-Wick*	206
Brook near *Circourt*; east of the word *farm*, between *Denchworth* and *Challow Marsh* farm	205
Road from *Wantage* to *Stanford*, south-west of *W* in *Westmead*	240
Highest ground on the north-west of *Collier's farm*, towards *Baulking*	280
Canal about a mile south-east of *Longcott*	258
Highest point over the railroad, on the slope north of *Bourton*, 0·9 mile east of *Hackron Bridges*	319
River *Cole*, about ½ furlong west of canal at *Hackron Bridges*; (county boundary entering Wilts from Berks)	263
Roman *Ermine* Way; about ¼ mile south-east of *Stratton-St. Margaret's*	324
North Wilts Canal, west of *Lower Eastcott*, near the bottom of *E*	308
Brook at *Westcot*, about ½ mile from *Okus*	284
Brook under the turnpike and railroad at *Hunts-Mill*, about ¾ mile south-west of *Wotton Basset*	238
River *Avon*, about ¼ mile north-west of *Avon*; near the final *e* in *Newhouse* farm, 3⅛ miles north by east from *Chippenham* church	130
Level of the railroad at that place	170

III.—ON THE SOUTH-EASTERN RAILWAY, FROM LONDON, BY TONBRIDGE AND ASHFORD, TO DOVER.

This line was originally intended to join the Southampton railroad. The starting point has since been altered, and is not yet determined.	
The datum, or base of the section, is the Trinity high-water mark at *Vauxhall Bridge*.	
Height of datum above low-water at *Sheerness*	19·67 feet.
Level of *Mitcham Common* near the Workhouse	90
Entrance of a proposed Tunnel through the chalk, at *Woldingham*	365
Road to *Woldingham Church*, about ¼ mile south of the Church	790
Highest point of ground over the Tunnel, at the meeting of two roads, south of letter *W* in *Woldingham*	793
Oxtead Bridge, at the east end of the village: —(*Stream*, about 270 feet)	277
Brook south-east of the farm-house, about ⅛ mile south of *W* in *Willwood* Farm	188
Road to *Edenbridge*, about a furlong north of the cross roads at *Holdfast*	224
Brook east of *Bowbeach* farm, where crossed by road to Tonbridge	106
River *Medway*, south-west of Powder Mills, and 1½ mile from *Tonbridge*; west of the *y* in *Medway*	60
General level of surface, from the road east of *Tudely* church (70 feet), to a road west of *Hoghill Green* (53)	60
Main road from Tonbridge to *Tonbridge Wells*; about ⅛ mile from the separation	79
—— to *Hastings*	67
Road at *Rat's Castle*, on the eastern verge of *Paddock Wood*	35
River *Teise*, south-west of the final *e*, near Bockenford	30
Road to Maidstone, immediately on the north of *Marden*; west of letter *M*	83
River *Beult*, about 0·4 mile south by east of *Hockenbury Bridge*	30
Road from *Cranbrook* to *Charing*, at Hoghill Green	97
Stream about ½ mile east of *Ninhouse*, about two miles south-west of Ashford	135
Road about ⅛ mile south-west from *Mersham* Church	162
Road from *Sellinge* to *Hythe*, about ⅛ mile from *Grove Bridge* over the Stour	193
River *Stour*, south of *Stanford* Church, about 1½ mile from its source near *Postling*	230
Summit of the sand heights cut by railroad near *Stone Farm*	325
Stream at *Beachborough*, nearly south of the summer-house, 0·3 mile west of the word *Mill*	166
Ground at *Cheriton Tile-pits*	155
Streamlet (valley of the gault), about ½ mile from *Inbrook*, south of St. Thames's Well	83
Ground at base of *Martello Tower*, No. 1	241
[The same place above *low*-water, barometrically F. 261	
Deduct diff. of tides, (at Folkstone) 21	240]
Height of the *chalk cliff*, at the beginning of the undercliff east of *Copt Point*	465
Height of proposed termination of the railroad, near the *Arch-cliff fort*, Dover; 58 miles 7 furlongs from London	107

A change

Stations.	Height above the Datum.
	Feet.
SOUTH-EASTERN RAILROAD (*continued*).	
A change in the beginning of this line has been since proposed, which will carry it through *Godstone* and *Tandridge*. The following are some points on the new section :—	
Road from *Croydon* to *Addiscombe*, north of N in CROYDON	209
Park hill; top of ridge, south of letter *a*	263
Combe lane, bottom of *C*	210
Road from *Croydon*, near *Purley House*, bottom of letter *H*	254
Hill on which is the *old London road*, south of *l* in *Riddles' Down*	407
Opposite to the road to *Cattersham*	413·69
Beginning of the proposed Tunnel, west of *Tillingdown* farm	473
Highest ground above the Tunnel	573
Road at the Dog-kennel (Marden Park ?)	460·05
Road, or lane, from the *Oxtead* road to *Godstone* Church	383
Road to *Tandridge* Church; near *k* in *Old Park Wood*	382
Road from *Oxtead* to *Crowhurst*, south of the turn to *Whitehall*; about 0·05 mile from *S* in *Stockhurst*	235
Brook, between *Jincock's* and *Stookhouse* farms	213
Road from *Crowhurst* to *Limpsfield*, at *Milston Wood*, about 0·1 mile south of letter *t* in *Milston*	292
Road at *Willwood* farm	236
Brook about $\frac{1}{8}$ mile south-west of *Willwood Farm*	187
[The new line hereabouts joins that first projected.]	
Road to *Edenbridge*, immediately on the south of road from *Hole Farm*	224

IV.—SIR JOHN RENNIE'S LINE OF RAILROAD, FROM LONDON TO BRIGHTON.

The beginning of this line, in the section laid before Parliament, is at *Kennington*.	
The datum, or base of the section, is the Trinity *high-water mark* in London.	
North-eastern angle of *Mitcham Common*	107 / 97·25
Smithham Bottom, near the road from Croydon to Merstham; letter P. of T.P.	200
Same road, south-west of buildings called *Old brewhouse* in the Ord. map	225
Road to *Coulsdon*, at the place where it strikes off from the main, about $\frac{1}{2}$ mile south of the *Red Lion*	297
Above *Hooley House*, on a line through the second *o* in the former word	323
Turnpike-road, where crossed by a line drawn through the words *Cottage*—(*Stoney Cottage*), and *Downs*—(*Farthing Downs*)	303
Ground above the railroad, opposite to the *Star Inn* near Chipstead; between the letters *t* and in *a Star*	358
Road (above the proposed Tunnel) from the *Turnpike* to *Dean's Farm*; about three fourths of the distance from the Turnpike road	397
Highest point of ground over the proposed Tunnel at *Merstham Hill;* about 4$\frac{1}{2}$ furlongs south of the point last mentioned	498
Turnpike-road north of Merstham, at the *Jolliffe Arms*, north of the letters *ge* in *Parsge.*	363
Ground near the *Windmill, Merstham*, on the ridge of the Upper green-sand (firestone)	362
Millstream, west of the bottom of letter *M* in *Mill*	285
Stream, where cut by a line from the top of the letters in the word *Linkfield*	232
Road from *Nutfield* to *Reigate*; immediately on the south of the second *a* in *Tanyard*.	238
Earl's Wood Common; on a line with the lower part of the word *Common*, on the east	190
Height east of *Pertridge Common*; at the first *o* in the word *Wood*	233
Stream, a tributary of the *Mole*; immediately above, and north-east of the letter P. in T.P.	167 / 156??
Stream tributary to *the Mole*, between the two letters *B* in *Bonehurst Bridge*	152
[From the brook at *Bonehurst Bridge*, to that north of *Hazlick Mill* (more than 4 miles), the surface is nearly flat; on the Weald-clay.]	
Brook, about 2 miles south of the place last mentioned; above the second letter *e* in *Horley-lane* Farm	165
Lane dividing Surrey and Sussex; south-west of the second *a* in *Oakland*	145
Stream at *Hazlick* Mill; where crossed by the road from Jordan's Farm to Wakeham's Green	154
River *Mole*, near the road from *Crawley* to the Workhouse, south of the letter *g* in *Three Bridges*	217
[Near this place, the ground begins to rise into the Forest ridge, (Hastings-sand).]	
The *Mole* river, in *Tilgate Forest*; on a line with the word *Tilgate*, and north-west of letter *C* in *Cinder Banks*	254
Ground in *Tilgate Forest*, about half a furlong north of *re* in *Green Trees*	304
Ground over a proposed Tunnel through the summit of *Balcombe Down*; (about a furlong east of the letter *B* in *Balcombe*)	439
Road from *Cooper's Corner* to *Balcombe Church*; at the letter *e* in *Cooper's*	293
[A rapid descent of very irregular ground succeeds.]	

Stations.	Height above the Datum.
	Feet.
Stream of the *Ouse* River; immediately on the south of the letters *l* and *s* in *Pilsty*	54
Highest point of ground over a proposed Tunnel through the heights north of *Cuckfield*; about half a mile south of letter *a* in *Taylor's Barn*	371
[Irregular ground, rapidly declining, succeeds for about 2 miles.]	
Stream of a large branch of the *Adur*; about 2·1 miles directly south of the bottom of letter E in the word CUCKFIELD, and about 2 miles west of *Wivelsfield*	49
[The surface here for about 4 miles is very irregular; the greatest height, about 250 feet; the average, 80 to 100.]	
Stream, south of the letters *Oa* in *Friar's Oak*	98
Road from *Hurster Point* to *Keymer*; where cut by a line drawn from *r* in *Friar's*, through *a* in *Wickham*, north of Clayton	165
Road, from the London road to Brighton, towards the Windmill on *Clayton Hill*; south of *D*, and north-west of *G*, in the words *Duncton's Gate*	382
Highest point of ground, over a proposed Tunnel through the chalk; about half a furlong south of the point last mentioned	458
[*Ditchling Beacon*, 2½ miles eastward,—(the highest point of the chalk range in this neighbourhood,) is, according to the Ordnance Survey, 858 feet above *low* water.]	
Exit of the proposed Tunnel, about ¼ mile north of *Pangdean*	204
[The ground thence descends rapidly and uniformly towards Brighton, along a valley of the chalk.]	
Lane to the church at *Patcham*, about 0·1 mile from the turnpike road	164
Termination of the proposed railroad, on the *Lewes road to Brighton*, near the *Royal Garden*	82

V.—MR. STEPHENSON'S LINE OF RAILROAD, FROM LONDON TO BRIGHTON.

This line is intended to strike off from the Southampton railroad. The datum or base of the section is consequently the same as of that line; viz. the Trinity high-water mark at *Vauxhall Bridge*.	
Road from *Wimbledon to Merton*, ¼ mile south of *ed* in *Wimbledon*	54
Road on *Merton Common*, to Cannon Hill; west of the top of letter *C* in *Common*	39
Stream from *Pylford Bridge*, crossed by railroad about 0·2 mile north-east of letter *P* in *Park Farm*	54·4
Height at *Sparrow Farm*	141
Road from *Kingston* to *Ewell*, over a small ridge; between the end of the word *Ewell* and *Court*	104
Stream of the *Hog's mill* river; at a point due south of letter *C* in the word *Court*	72
Road on the northern verge of *Epsom Common*; at a point due north of letter *o* in *Epsom Wells*	172
Highest point of ground over a Tunnel through the ridge on *Epsom Common*; 0·1 mile due south of the second *m* in the word *Common*	244
Height of the railroad at the exit of the Tunnel	153
General level of the ground, on the south-west of the ridge, by Duke's Hill, to the north-west of *Ashstead*	156
Road from London to *Leatherhead*, north of the first letter *e* in *Leather*	169
Road from *Leatherhead* to *Dorking*, east of letter *M* in the words *R. Mole*	125
River Mole, due south of the letter *e* in *Mole*; nearly on a line joining the words *Fetcham* and *Mickleham*	93
Highest point of ground over an intended Archway in *Norbury Park*; north of the letter *r* in *Norbury*	225·5
Level of railroad at bottom of Archway	134
River *Mole*; immediately south of the Archway, and of letter *y* in *Norbury*	98
River *Mole*; about 0·8 mile south of the last place, north of letter *e* in the word *Westhumble*	108
Millstream, ⅛ mile north of letter *P* in *Punchbowl*	128
Road from *Dorking* to *Reigate*, at the cross-roads south-east of the words *Punch Bowl*	184
Highest ground over a proposed Tunnel, about 0·35 mile from the cross roads last mentioned; south-east of G in DORKING	345
Height of the bottom of Tunnel at its exit	82
Lane or road, west of letter P in Park Farm	218
Stream between two lanes north of letter *S* in *Scammet's Farm*	165
Stream (another tributary of the Mole, springing on Holmwood Common); at a point south of the second *m* in (*Brockham*) *Common*	207
Stream which runs to *Ewood Pond*; on the north-west margin of a wood, about ¼ mile from the edge of the pond	205
Height, in the wood, between the words *Henfold* and *Park Gate*	285
Streamlet on the south of the wood, due east of the word *Knole* Farm	221
[The highest point of the railroad hereabouts, is between the streamlet last mentioned and the village of *Newdigate*, and is 247 feet above the datum. The road then declines rapidly to Warnham, and thence to the seaside.]	

Stations.	Height above the Datum.
	Feet.
Mr. Stephenson's Brighton (*continued*).	
Brook between *Green's Farm* and *Rushet*, where crossed by a line joining letters *n* and *t* in those words	213
Highest point of ground cut by the railroad, on the east of *Plaistow Farm*, 1 mile from the point last mentioned	297
Boundary of the counties of *Surrey* and *Sussex*; immediately above letter *M* in *Muggeridge Farm*	213
Brook on the east of the London Road, about 1·7 mile south of *Kingsfold*; and 1·15 mile from *Warnham*	153
Brook south-east of *Slaughter's Bridge*, under the letter *B*	155
Height, east of the main road, on the west of a small wood above the words *Lake Barn.*	229
Stream, a tributary of the *Arun*, on the south-west of *Horsham*; north of the letters *ar* in *Farthings*, and a little south of west from the words Tower Hill	83
Railroad at the same point	140
Road from *Horsham* to *Worthing*; about 2¾ miles from the former, between the word *Prior's*, and a short lane leading to that farm-house	136
Heights cut through by the railroad, on the south-east of *Cobb's Hill*; about 0·1 mile south of letter *s* in *Tuckman's*	123
Two streamlets, south-east of the point last mentioned, where cut by the line passing from *a* in *Tuckman's* to *ha* in *Smallham*: the level in both is, about	40
Heights on the north of *Joulsfield Common*, east of West Grinstead; about 0·1 mile north-west of a Windmill	90
Road north of letter *a* in *Partridge Green*, about ¼ mile east of the main road to *Steyning*	25·5
Principal branch of *the Adur*, on the north-west of Henfield,—(called in the section *Henfield Cut*);—where crossed by a line connecting letter *e* in *Bine Farm*, with *L* in *Lashmer's*: nearly on a level with the Datum	0·0
[Thence to the seaside, the railroad follows the valley of the *Adur*; passing through the chalk range, by the defile of that river, to *Shoreham.*]	
Part of a hill cut through by a projected Tunnel north of Brighton, on the road to *Preston*, about 0·1 mile north of a windmill on its summit, is about	198

VI.—LONDON AND SOUTHAMPTON RAILROAD, BY BASINGSTOKE AND WINCHESTER.

This road begins on the bank of the Thames, near *Nine-Elms*, about ¼ mile south-west of *Vauxhall Bridge.*	
The datum or base of the section is the *Trinity high-water mark* at that bridge. The levels were ascertained under the direction of Mr. Giles, engineer to the Company.	
The height of the datum above low-water mark at Sheerness, is	19·67 feet
[The natural surface for about 2 miles from the point of commencement, across *Battersea Fields*, is 1 to 5 feet *below* high-water mark.]	
Road from *Battersea Rise* to *Wandsworth*, immediately on the west of the cross-road to Battersea	40
Highest point of ground on *Wandsworth Common*, about the letter *i* in the words *Half Farthing*	80
River Wandle, where crossed by the railroad, near letter *t* in *Garret Mill*	10
[From the foot of the height near *Kingston*, south-east of Surbiton, to *Walton Common*, is a continuous flat.]	
London and Portsmouth Road, on Ditton Marsh, south of letter *a* in *Marsh*	29
Railroad at the same point	45
Road from *Walton-on-Thames* to *Hersham Green*, at the turn to Burwood Park	37
Ground above the railroad, outside of *Oatland's Park*; directly south of the second *a* in *Oatlands*	103
Old River Wey, north-east of the letter *k* in *Hollick's* Farm	29
Wey navigation, at the commencement of the Basingstoke canal; south-east of letter *w* in *Ham Haw*	42
Road on *Woking Heath*, from Horsell to Heathside; under letter *W*, and immediately west of letter *H* in *Heath*	90
Summit of a *ridge of sand* (called *Goldsworth* in the section); south of letters *Gr* in *Royal Oak Green*, and west of the word *Crossland*	185
Stream on the north-east of *Pirbright Common*, south of letter *m* in *Hermitage*	103
Height on *Pirbright Common*, north of letters *ir* in *Pirbright*	173
Ground at the eastern angle of *Furzehill Pond*	168
South east extremity of *Lodge Pond*, on Pirbright Common; south of the canal at *Leatherhead Hill*	227
Highest ground between *Lodge Pond* and the canal at *Frimley* Wharf; about ⅛ mile north-west of the word *Lodge*	272
Basingstoke Canal, west of the word *Wharf.*	235
Ground at *Blackwater Brook*, or River, dividing the counties of Surrey and Hants; about ⅛ mile south of *F* in *Frimley Green.*	192

Stations.	Height above the Datum.
	Feet.
Road from London to *Farnham*; $\frac{1}{8}$ mile south of the word *hill* in *Windmill-hill* ...	217
Stream where crossed by a line joining the words *West-heath* and *Workhouse*	188
Highest ground on the line east of *Fleet Pond*; 1 mile from the point last mentioned.....	224
Margin of *Fleet Pond*, north of letter *F* in *Fleet*	214
Height west of *Fleet Pond*; $\frac{1}{2}$ mile south of letter *a* in *Broomhall*, and 0·4 mile west of the pond's edge	245
Ridge about $1\frac{1}{4}$ mile west of *Fleet Pond*, and $\frac{3}{4}$ mile east of letter *F* in *Greenham's Fm.*	237
Stream, between the letters *m* and *s* in *Greenham's F*.....	187·5
Highest point over the railroad at *Shapley Heath*; between the letters *e* and *a* in the word *Heath*	307
Railroad at the same point	247
Whitewater River, at the separation of two branches, south of the word *Holt*.....	200
Road from London to Basingstoke, on *Hook Common*; about $\frac{1}{2}$ mile from the cross roads in Hook village	293
Height cut through by the railroad, $\frac{1}{4}$ of a mile from *Newnham Church*	301
Stream on the south-west of *Newnham*, and 0·08 mile north of the *io* in the words *Red Lion*	198
Highest point of ground cut through by the railroad between *Newnham* and *Old Basing*; 0·35 mile south of letter *M* in *Basing Mill*	292
Road at *Old Basing*, west of top of letter *O*.	254
Mill Head, *River Loddon*; $\frac{1}{2}$ mile west of bottom of the word *Old*	224
Main road from *Basingstoke* to *Reading*; on a line with the bottom of the word *Penton's*, in *Penton's Mill*	307
Road from Basingstoke to Whitchurch, at *Worting*, about midway from the cross roads to the church	318·75
Railroad at the same point	341
Height south of the word *Worting*	362
Road from *Church Oakley* to *Fairdown Copse*; about 0·63 mile from the church, on the south-east	404
High ground about $\frac{1}{8}$ mile south of the place last mentioned	420
[This point is a little higher than the general range of the heights between *Worting* and *Steventon*.]	
Railroad, 38 feet lower	382
Highest ground, south-west of *Steventon Church*; in a wood east of road at *South Wood*	456
Depression on the south-west of the height last mentioned; northern extremity of *Cobley Wood*.....	374
Height at the angle of an inclosure, west of the words *Popham Beacon*	454
Railroad (83 feet below)	372·5
West side of the inclosures at *Warren's Farm*.....	315·3
Depression 0·7 mile south-west by south of *Warren's Farm*; north of *S* in *Sheep Ho.*	268
Height north of *Sheephouse Farm*, about $\frac{1}{8}$ mile north of top of letters *Sh*.....	313
Stream and road near *Weston*, about 0·86 east of the church at *Stoke Charity*.....	208·5
Railroad at same place, 84 feet above	292·5
Height about 0·15 mile south-west of the cross roads between *Waller's Ash* and *Lunway's Inn*	347
Ground in a road south of letter *F*, in *Hook Pit Farm*	164
Summit of height on the east of *New Farm*.	228
Road immediately on the south of *h* in *Headborne Worthy*	152
Turnpike road from *Winchester* to *Andover*; east of the words *Turnpike gate*, on the road to *Week*.....	177
Railroad at the same place	177
Height on the north-east of the point last mentioned.....	217
Road from *Winchester to Southampton*, about 0·1 mile from the first *s* in the words *St. Cross*.....	146
Railroad at the same point	130
[From this place to the shore, *east of Southampton*, the railroad follows the line of the *River Itching*, with a nearly uniform descent.]	
Road at *Allbrook*, crossing the *Itching navigation*	41·5
Railroad at the same place.....	52·5
Road from *Southampton* to *Twyford* and Winchester, about $\frac{1}{2}$ mile north of *Swathling*	23
[The railroad reaches the level of the London high water-mark, within the grounds of *Portswood House*.]	

D.—ADDITIONS AND CORRECTIONS.

Coast west of Hastings.—The alterations and improvements on the coast west of Hastings were so rapid, soon after the preceding pages 163. to 171. were written, that, within a few weeks, an entirely new face of the cliffs was brought to light; a great part of the original surface having been cut away, so as to throw back the vertical section to a much greater distance from the sea, while the debris were employed in raising a quay, by which the shore is now concealed. The Rev. Granville Vernon Harcourt, who had examined the new features thus disclosed, was so good as to point out to me several appearances, which proved that the structure of the shore was not quite so simple as I had supposed it to be, though the sections above described, and that represented in Plate X. b. fig. 3., are in the main correct. Several intermediate though slight derangements occur between the principal fault at the White Rock and the site of the church west of St. Leonard's; and the whole of the phenomena show that the original stratification hereabouts has been fractured and dislocated throughout, although the disjointed portions are seldom widely separated.

It would be impossible, without the aid of a map on a very large scale, to represent these derangements, nor have they more than a local interest. The place of one of the principal interruptions between the White Rock and Warriors' Gate is represented in Pl. X. b. fig. 3.; and the beds composing the group thus divided, which, on the east of that point, dip slightly towards the sea (or to the west of south), could be detected in several places within (or north of) the *Marina* at St. Leonard's, in the sides of the new roads and streets then in progress, inclining, generally, to the *north*. Their identity could be traced by the aid of two thin beds of greenish Fuller's earth, frequently concurrent, but sometimes about 4 or 5 feet apart, and separated by about 8 feet of grey sand and sandrock, from a bed of dark grey clay, much charged with portions of lignite, in which indications of vegetable structure were perceptible, but none so distinct as to indicate the species. These beds are all superior to the Endogenite group of the White Rock; and their distance above that group, on the north-east of St. Leonard's church, was clearly seen to be nearly the same as at the White Rock. At the roadside, on the east of St. Leonard's church, I myself found a specimen of Endogenites, at the place mentioned by Mr. Parish from report.

The greater part of the ground formerly above the White Rock had been removed by the operations above mentioned, and the fault there was distinctly uncovered to the extent of several yards. The strata which form the cliff at the brewery descend gradually to the sea, without apparent disturbance, but the ruins of the superior strata, including numerous fragments of the lignite bed, were mixed in great confusion on the western and upper side of the fault; which rising gradually towards the north-east, seemed to cross the valley there separating the cliffs from those of Hastings Castle Hill, in a direction from about south 35° west to the east of north. On that line a wide but not deep fissure, or ravine, could be discerned passing towards the place called *Bohemia*; and on the opposite side of the valley, a detached portion of confused matter, including, as at the White Rock, masses of clay iron ore, was visible in a highly inclined position, at the corner of one of the lanes descending from the Castle Rock to the marsh. It is not improbable that the fault may be continued further up the valley on the north-west of Hastings.

Bones of Birds in the Wealden.—Mr. Mantell, in a short paper read before the Geological Society, June, 1835*, has shown by anatomical evidence that the bones found at Tilgate Forest, and

* "Proceedings," vol. ii. p. 203.

suspected to belong to Pterodactyles, were correctly referred to birds. On placing some of the questionable fragments before Mr. Owen, of the College of Surgeons, that gentleman found, in a tarso-metatarsal bone, the articular surface and place of attachment of the posterior, or opposite toe, distinctly indicated; and on a comparison of these fragments with the foot of a recent *Ardea*, no doubt remained as to the similarity of their structure. This short paper beautifully illustrates the bearing of exact comparative anatomy upon Geology.

Supposed Wealden in Northamptonshire.—Mr. Lonsdale having, during the last summer, resumed his examination of the oolitic system, and followed out the series from the north of Oxfordshire to the Humber, informs me, that he did not observe any traces of the Wealden in the vicinity of Wansford; which is mentioned at p. 309. as the place where a beautiful specimen of *Lonchopteris Mantellii* was supposed to have been found. The tract belongs to the great oolite, which is the highest formation, and is extensively quarried in every direction around Wansford: on the west of Peterborough, the highest formation is the cornbrash. Mr. Lonsdale, therefore, thinks that the occurrence of any portion of the Wealden group in such a situation, is extremely improbable, and that the specimen above referred to may have been ascribed to that place by mistake.

Supposed Chalk in Rutlandshire.—The existence of Chalk, *in situ*, at *Ridlington*, in Rutlandshire, Mr. Lonsdale considers also as being very improbable. The village stands on the ferruginous sand of the inferior oolite; about half a mile west of it, is a small pit of the bottom beds of the great oolite, now a subsided mass: and great oolite is quarried near Brooke Hall, two miles north of Ridlington; but with the exception first mentioned, there is no trace of any stratum superior to the inferior oolite, in the immediate neighbourhood of that village.

Inoceramus intermedius.—This fossil, which is mentioned at p. 317, as from Hunstanton cliff in West Norfolk, is a new species, ascertained by Mr. Sowerby; by whom a drawing of it was made, for a Wood-cut, published in Loudon's "Magazine of Natural History," for 1829, vol. ii. p. 296. Mr. Sowerby informs me that its occurrence is not unfrequent in the flinty chalk of Norfolk and Kent; and that it is found occasionally, in flint, in the gravel around London.

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APPENDIX.

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V.—*Zoological Observations on a New Fossil Species of Chelydra, from Œningen.*

By THOMAS BELL, Esq., F.G.S. F.R.S.

[Read January 18, 1832.]

THE *Testudo serpentina* of Linnæus appears long since to have been considered as constituting a distinct generic form by the accurate Schweigger, who applied to it the name Chelydra; but from the paper in which this distinction was first given to the world being little known, this tortoise has since received the generic appellations of Saurochelys, applied to it by Latreille, of Chelonura by Fleming, and of Rapara by Gray. The last-mentioned author has, however, very properly restored the name first given to it, in his *Synopsis Reptilium*, the first part of which has recently appeared.

The extraordinary length of the neck and tail, the great comparative breadth of the head, and especially the shape of the sternum, sufficiently distinguish it from every other form of the Testudinata. The sternum is very narrow and lozenge-shaped; and the ramus of the sternum (constituting on each side the symphysis between its body and the sterno-costal suture) is exceedingly long and narrow, so as to give the whole somewhat the form of a cross.

One recent species only has hitherto been discovered, the *Chelydra serpentina*; and I cannot find any mention of fossil remains of the genus in any work that I have been able to consult. The fine specimen which I will now proceed to describe is, however, fortunately, sufficiently perfect to leave not a moment's doubt of its relation to this genus, whilst it also retains sufficient osteological characters to establish it as a distinct species.

Of the specimen itself*, although but little of the dorsum remains, it is evidently the *upper* side of the sternum which is exposed, as is shown by some portions of the dorsal margin, which are still seen lying over the limbs as they emerge from the carapax. This is most obvious at the part where the left humerus may be observed, partly lying under the marginal extremity of the anterior ribs. With this exception, therefore, the whole of the dorsal portion is wanting, having most probably been removed with the superincumbent

* Plate XXIV.

layer of the stone when the mass was split. It is necessary to state these particulars, as a superficial view of the specimen would convey the impression that the under surface is the one exposed.

The following tabular view of various parts in the recent and fossil species will show at once the distinctions which exist in their relative proportions. It is necessary to bear in mind that the skeleton of *Chelydra serpentina,* from which the measurements in the second column were taken, is considerably smaller than the fossil. The dimensions are given in inches and tenths of an inch.

	Fossil.		Recent.	
	In.	Tenths.	In.	Tenths.
Length of the dorsal shell	18	0	11	0
Breadth of the dorsal shell at the union with the sternum	14	5	9	5
Breadth of the dorsal shell rather further backwards	15	5	9	5
Breadth of the sternum at the symphysis, including the expansion of the rami	12	0	8	5
Breadth of each ramus of the sternum at the narrowest part	1	7	0	5
Length from the central union of the bones of the sternum to the posterior margin of the dorsal shell	10	5	6	0
Length of the tail beyond the margin of the shell	12	0	6	5

From a comparison of these details, we find that, taking the dimensions of the dorsal shell as the standard, the following proportional differences exist between the fossil and recent species. The expansion of the upper shell in the fossil is greatest at some distance posterior to its union with the branches of the sternum ; that of the recent is widest at the union. The breadth of the lateral branches or rami of the sternum, in the former, is not less than one eighth of the whole breadth of the sternum ; in the latter it is not more than one seventeenth. These differences, with the much greater comparative length of the tail in the fossil species, warrant me in considering it as a distinct species, to which I propose to give the name *Chelydra Murchisonii,* after the distinguished president of this Society, to whose kind interference I owe my possession of it. To his pen I leave the detail of every particular relative to the geological situation of the specimen *, but I think it may not be uninteresting to state a few facts illustrative of the habitat and manners of the recent species, especially as the organization of the two species is so similar as to preclude the possibility of any considerable difference in their habits.

The *Chelydra serpentina* is strictly and exclusively an American form. There is no approach to it in any species inhabiting the Old World. It is found in the southern states of North America, where it is known by the name of the snapping turtle. It has also been termed the alligator tortoise,

* Geological Transactions, Second Series, vol. iii. p. 281.

an appellation which it has derived from its general form, especially the deeply carinated tail, as well as from its predatory habits. It is strictly a freshwater form, and is highly carnivorous, seizing its living prey with great avidity, and with a sudden snapping movement; to which circumstance it owes its common name. Its food consists of young water-fowl, fish, and aquatic reptiles; and the length of the neck, the strength of the jaws, and the robust and sharp claws with which the feet are armed, are admirably adapted for seizing and tearing its prey. I have observed in several specimens which I have kept living, that when teazed they will remain for a time motionless, the head withdrawn underneath the shell, until, at a convenient moment, the head is thrown forwards by an instantaneous extension of the neck, and the object of its attack seized by a sharp sudden snap of the jaws. I have seen a stick nearly as large as the little finger snapped in two by this sudden movement.

It frequently wanders to a considerable distance from the lakes in which it habitually resides, and is said to hybernate either in mud or in the ground near the water. A specimen which I possessed last year repeatedly endeavoured to dig a retreat for itself in soft earth, which it removed by its fore feet with great rapidity, entirely concealing itself in the space of a few minutes. The whole of the freshwater forms are strikingly contrasted with those of the terrestrial group, in the ease and rapidity of their movements, and in their carnivorous habits, for the enjoyment of which these qualities are essentially required; and the group to which the present genus belongs may be considered as possessing those powers and habits in the greatest degree, with the exception, perhaps, of the family of the *Trionychidæ*, which, however, if they exceed the former in the quickness of their motions, must yield to them in strength.

VI.—*On the new Red Sandstone Series in the Basin of the Eden, and north-western Coasts of Cumberland and Lancashire.*

By the Rev. ADAM SEDGWICK, F.R.S. V.P.G.S. &c.
(WOODWARDIAN PROFESSOR IN THE UNIVERSITY OF CAMBRIDGE.)

[Read February 1, 1832.]

Introduction.

IN two papers read before the Geological Society during the Sessions of the past year*, I endeavoured to describe the phænomena exhibited along the line where the carboniferous chain of Yorkshire and Westmoreland strikes against the old slate rocks of the Cumbrian mountains. Taking up the subject where it had been left by Mr. Phillips†, a series of enormous faults and dislocations were traced, nearly along this line of junction, to the foot of Stainmoor; and it was shown that mountain masses of rock, torn off from the carboniferous series, were thrown down with a reversed dip into the higher part of the valley of the Eden, near Kirkby Stephen; and that after many breaks and contortions, they gradually gained a more regular strike and dip, and were prolonged into a chain, forming the northern outskirt of the primary Cumbrian system, and terminating at Egremont. It was at the same time shown that another fault, ranging under the escarpment of the Cross Fell chain, produced a corresponding effect on that part of the carboniferous series; and that both these great disruptions took place at a period anterior to a portion of the conglomerates of the new red sandstone‡.

In this paper I purpose to give a sketch of the new red sandstone series, which spreads from both banks of the Eden to the base of the neighbouring mountains, and afterwards skirts the coasts of Cumberland and Low Furness. In performing this task I shall endeavour to describe in order,

1st, The geographical distribution of the red sandstone series, and the features of the country through which it ranges;

2ndly, Two or three masses of older rock, which appear within the limits of the red sandstone;

* Geological Transactions, Second Series, vol. iv. pp. 47, 69.

† Geological Transactions, Second Series, vol. iii. p. 1.

‡ See Plate XXV. fig. 2.

3rdly, The successive deposits entering into the red sandstone series, with a view to their comparison with the corresponding groups in Yorkshire and Durham;

4thly, By way of conclusion, I shall endeavour to give a general comparison of the red sandstone series of Scotland and England, in the hopes of thereby establishing some general subdivisions, by help of which the several groups may be brought into at least an approximate comparison with each other.

The details of this, and of the two other papers, will nearly define the geographical limits of the primary Cumbrian mountains, a general description of which I hope in a short time to lay before the Society.

§ 1. *Geographical distribution of the Red Sandstone Series, &c.*

Between the chain of Cross Fell and the primary Cumbrian mountains the red sandstone series fills a triangular area, the vertex of which may be placed in one of the tributaries of the river Eden, not far from Brough, and its base on the frontier of Dumfriesshire and the Solway Firth. Respecting the range of the north-eastern side of this triangular area, I have few details to offer which are worth recording; but I may state in general terms, that if the vertex be placed on the banks of the Belah (above the bridge on the road from Brough to Kirkby Stephen), the *boundary line* may thence be drawn, by Brough Castle and the north-eastern side of Brough Hill, to the foot of the carboniferous chain a little above Helton; and that in the remaining part of its course to the frontier of Scotland, it continues to skirt the chain very nearly, as is represented in Mr. Greenough's map*.

* During the summer of 1834 I examined a part of the Cross Fell chain with Mr. Bowstead, of Corpus Christi College, Cambridge; and from our joint observations, as well as from information he has had the kindness to communicate, I may add the following account of the north-eastern demarcation of the new red sandstone. After skirting the north-eastern side of Brough Hill, it ranges nearly in the direction of Burton; and the rock is seen, in the form of a highly calcareous conglomerate, in Walk Mill Beck. Thence the line ranges above Burton; and skirting the hills at a considerable elevation, passes under the base of Roman Fell (which is composed of disturbed beds of *old red sandstone*), and is prolonged a little above Helton, and just above Murton. Beyond the last-named village the line has, for a few miles, a more westerly range, so as to pass considerably below Keisley; after which it is, by a more northerly course, brought a little above the village of Dufton, from which it may be traced across Swindale Beck, near the village of Knock. From this place the line (still skirting the hills at a considerable elevation, though the beds of red sandstone are nearly horizontal) may be traced above Milburne, Ouseby, and Melmerby; through Raven Beck, a little above Renwick; and just above Croglin, from which place it is prolonged near the base of the great carboniferous escarpment, as may be seen in numerous sections where the rocks are laid bare

The direction of the south-western boundary has been ascertained much more correctly, by observations carried on from one end of it to the other. Its minute description is, however, thrown into an appendix, being necessarily made up of details, which, though tiresome and uninstructive if read before the Society, may assist in the completion of our geological maps, and be of some value as matters of reference. Such facts only will be mentioned here, as throw light on the structure of the red sandstone, and help to establish its subdivisions.

Where the red sandstone series first appears in the ramifications of the Eden, near Brough and Kirkby Stephen, it is chiefly seen as a conglomerate, abounding in fragments of mountain limestone, and cannot, when it has that form, be mineralogically distinguished from the overlying conglomerates on the skirts of the Mendip Hills. It is generally in a state of complete induration where the calcareous fragments abound; and it sometimes passes into mere brecciated beds of limestone: but other parts, especially where the pebbles are rounded, and the sand and cement abundant, are soft and crumbling. In the arrangement of the several varieties of the formations, though the beds are nearly horizontal, there is very little approach to symmetry or order. Hence the conglomerates offer a very unequal resistance to the action of the elements; and above Kirkby Stephen, where the Eden makes its way through them, they have been worn into channels of extraordinary complexity. Chasms and deep basins are naturally scooped out where the rock offers the least resistance; and by these inequalities great eddies are formed in the river during every mountain flood, which by whirling round the hard pebbles at the bottom of each basin, gradually grind away the solid rock, and carry on the work of excavation far below the surface. Caverns are thus formed; and masses of conglomerate become so far undermined, as sometimes to allow a new passage to the river far below the level where it once flowed.

A fine example of this kind occurs at Stenkreth Bridge near Kirkby Stephen, where the waters, after washing the inclined strata of mountain limestone below Pendragon Castle, plunge among the horizontal masses of conglomerate; after which, for a short space, they are heard roaring in a subterranean channel, communicating by a narrow cleft (called the span of the Eden) with what

by mountain torrents. Further towards the north the calcareous chain declines in elevation, and the demarcation of the new red sandstone is often ill defined. The best approximation to its course that has yet been published, may be seen in Mr. Greenough's map. It passes (as there represented) to the east of Brampton, after which it ranges, in a sinuous line, very much concealed by alluvial detritus, but on the whole bearing nearly due north till it crosses the Liddel and enters Scotland; then it is deflected nearly to the west, and crosses the Esk just above Canobie Bridge.

appears to have been the ancient bed of the river. Within the memory of man this cleft might be spanned by the human hand; but it is now, by an act of wanton mutilation, despoiled of a portion of its honours, so that the projecting ledges of rock, at their nearest point of approach, are about two feet asunder.

A little way below Kirkby Stephen the conglomerates are in a state of extreme induration, and rise in large flat beds, sometimes used for coarse flagstones and coping-stones, a purpose to which the conglomerates of the new red sandstone are also applied in the neighbourhood of the Mendip Hills.

The relations of the overlying series are extremely obscure for several miles below Brough and Kirkby Stephen, being much concealed by enormous masses of transported materials. The new red sandstone is however seen, in several places, in the channel of the Eden, and the line of demarcation passes, on the whole, considerably to the south of its left bank*. In the rivulet which descends to Little Ormside, and at Burrels, to the south of Appleby, the conglomerates are again exposed; and (though the sections are obscure) appear, from their position, to be at the base of the red sandstone series†. Near Burrels they form a fine escarpment, parts of which contain large fragments of mountain limestone (sometimes rounded but generally angular) and are extensively burnt in the neighbouring kilns: other parts of the escarpment are of a finer structure, rise in thick flaggy beds, and are used for building. The imbedded pebbles and fragments of gritstone and limestone seem to be derived exclusively from the neighbouring carboniferous formations; and are held together by a red, calcareo-ferruginous cement, more or less mixed with siliceous sand, and in a very variable state of induration. Subordinate to the cement (which does not, as in some parts of England, contain an excess of magnesia) are a few concretionary nodules of red oxide of iron.

The range of the demarcation through the remaining part of Westmoreland, till it crosses the Eamont below Eamont bridge, presents no phænomena of much interest. It, however, deserves remark, that in this district, especially near Cliburn, the red sandstone is sufficiently hard and thin-bedded to be used

* In this portion of the range, by far the greatest area of the red sandstone is expanded beyond the right bank of the Eden. Partly in consequence of the great fault above noticed, all the older formations, near the base of the Cross Fell chain, have a high angle of inclination, and must have once formed a deep trough for the reception of the newer deposits. As a natural result of this position, the red sandstone is often found abutting against the inclined strata close to the base of the chain; which throughout presents a steep escarpment towards the neighbouring plain. The south-western boundary of the red sandstone rests (on the contrary) on slightly inclined beds of the carboniferous series; and is, consequently, thrown off to a great distance from the primary central groups, and in one or two places approaches very near to the left bank of the Eden.

† See Plate XXV. fig. 3.

for roofing-slate. In England such a structure must be considered rare; but in Dumfriesshire the new red sandstone not unusually rises in flaggy beds which are, I believe, sometimes applied to a similar purpose.

The further range, to the coast of Cumberland, is detailed in the Appendix (p. 405); and it is sufficient in this place to state, that the line of demarcation incloses Penrith Beacon, Thiefside Fell, and the great quarries of Highhead Castle; and that, after skirting the Bolton coal field, it stretches in a direction nearly east and west, and runs into the sea on the south side of Maryport. Along this line there are no traces of conglomerates (like those above described); nor, in general, is there anything in the position of the red sandstone beds to prove that they are unconformable to the carboniferous beds on which they rest*. They make no regular escarpment, and there is moreover a difficulty in determining their exact limits, of which those who have only studied the types of our south-western coal fields can hardly form a just estimate. The gritstone beds of the carboniferous series are, here and there, of a deep red colour, and cannot always be distinguished from the new red sandstone. Moreover there seem to be, along some portions of this line, traces of a lower red sandstone, forming a connecting link between the true carboniferous rocks and the formation I am now describing†.

Between the south-western boundary of the new red sandstone and the banks of the Eden, there are many tracts of wild sterile land. For the rich gypseous marls, which give so much fertility to the great plain of central England, are there almost entirely wanting; and the subsoil is composed of a barren sandstone, on the parallel, if I mistake not, of the forest sand of Nottinghamshire. This sandstone has been exposed to great degradations since the time of its first deposit; but by taking the height of Penrith Beacon, and adding to it the depth of the borings in search of coal, near its base, we have a proof that the portions of red sandstone, still remaining, are in some places of a very great aggregate thickness‡.

The great degradation of the red sandstone is proved, not only by the

* The neighbourhood of Rosley seems an exception to this remark, for the coal strata are there much shattered, and in some places highly inclined, while the overlying formation of red sandstone is nearly horizontal.

† Among the dislocated and highly-inclined beds near Brough, the grits of the carboniferous series are generally iron-shot, and not unusually of a deep red colour. Rocks of a similar colour, but of more doubtful relations, occur near the line of the road between Penrith and Newton Raney; also in the same neighbourhood near Catterlem and Hutton. Again, a few miles west of Maryport, there are examples of a red grit (probably portions of the "lower red sandstone") near the demarcation above noticed.

‡ At a place called Honey Pot, close to the banks of the Eamont, a little below Penrith, they

outline of the country, but also by the enormous masses of drifted materials by which it is accompanied. It is no part of my object to describe these materials in detail; but I may here remark, that mingled with them, and overlying them, are great bowlders of Shap granite, which have been drifted over the hills and plains skirting the Eden from Appleby to the foot of Stainmoor*; that enormous masses of Carrock Fell syenite and other crystalline Cumbrian rocks have been drifted as far as the shores of the Solway Firth, where they are found mixed with other great bowlders, brought by opposite currents from the mountains of Dumfriesshire; and lastly, that the red sandstone is often buried, for miles together, under great heaps of the old alluvial detritus, which has modified all the external features of the region, and sometimes produced a fertility little known where the undisturbed rock is near the surface.

From the red cliffs of Maryport to St. Bees Head (a distance of thirteen or fourteen miles, estimated in a straight line), the whole coast is occupied by the coal measures, excepting one place a little north of Workington, and two or three places near Whitehaven, where we find an intermediate sandstone, forming, apparently, a connecting link between the true carboniferous and new red sandstone groups. The red sandstone of St. Bees Head appears to dip conformably to the coal measures, from which it is separated, not only by the intermediate sandstone before noticed, but also by the magnesian limestone and conglomerate which strike across the headland to Ben How quarry†, where they are cut off by the valley of St. Bees, to the south of which the yellow limestone is no more seen in Cumberland.

Notwithstanding the position of the beds at St. Bees Head, it is obvious that, when considered on a great scale, the formation is unconformable to the coal series; for the same beds, in their prolongation to Egremont, cross obliquely over the range of the mountain limestone, and the new red sandstone is expanded in irregular *outliers* far within the limits of the coal field‡.

Between Egremont and Gossforth, the formation appears to have undergone a movement of elevation; for its beds dip at a considerable angle to the west,

bored seventy-four fathoms in search of coal. It is said that they passed through only fifteen fathoms of red sandstone before they reached the coal measures.

* It is well known that the bowlders of Shap granite have drifted over Stainmoor to the plains of Yorkshire, and even as far as the eastern coast. They have also been drifted to the western coast below Milnthorp in Westmoreland; and they abound in the masses of gravel which are found near the tops of the high hills between Sedberg and Kendal. † See Plate XXV. fig. 4.

‡ These *outliers* will be laid down on a map to accompany a subsequent memoir on the Whitehaven coal field.

and the demarcation ranges at a high elevation along the flanks of the neighbouring mountains*. To the south of Gossforth, all the low region bordering on the coast is so much concealed by transported matter, that the red sandstone is visible only in a very few places: it, however, comes to the surface, or has been reached by artificial excavations, in several places north of Bootle, where it appears to rest immediately on the granite†. Indeed, all the cliffs for eight or ten miles south of Ravenglass are composed of a coarse red gravel, looking like materials formed by the breaking up of the red sandstone, and probably resting on it,—a conclusion confirmed by the appearance, during low spring tides, of two reefs of red sandstone (Brandreth Scar and Codlin Rock) not far from the coast. Between Bootle and Duddon Mouth no red sandstone has been found *in situ*, though the coarse red gravel extends several miles to the south of the former place. All the southern part of the promontory (with the exception of Hodbarrow Point, where there is a patch of mountain limestone), is, however, composed of marsh land or of drift sand‡.

To the south of the Duddon estuary, the red sandstone again appears in great force, overlying the carboniferous series; and though buried in many places under enormous mounds of diluvial gravel, there can be no doubt that it forms the subsoil of the whole south-western extremity of Low Furness.

It deserves remark in this place, that at Hole Beck, near Stank, in a very deep denudation, yellow, cellular beds of magnesian limestone are exposed at the base of the red sandstone §.

The red sandstone is probably also expanded under the low region at the south-western extremity of Cartmel Fells; as it is said to have been reached in two places by excavations, and it appears, as a very characteristic conglomerate, unconformable to the mountain limestone near Flookborough Spaw. No traces of it have, I believe, been discovered on the neighbouring coasts of Westmoreland and Lancashire; but it reappears (far beyond the limits of the country I am attempting to describe) in a small patch, at Westhouse, near Ingleton; as has been already noticed by Professor Phillips ||.

These detached masses of the new red sandstone prove, at least, that the formation was at one time expanded over a much larger surface than it is at present: indeed, there can be little doubt that it once extended, in a continuous mass, from the shores of Cumberland to South Lancashire and Cheshire. That much of it has been swept away, is shown by the whole aspect of the

* See Plate XXV. fig. 5. † See Plate XXV. fig. 6.

‡ By comparing this description with Mr. Greenough's geological map, it will be seen that he has extended the red sandstone of the Cumberland coast considerably too far south.

§ See Plate XXV. fig. 7. || Geological Transactions, Second Series, vol. iii. pl. 2.

neighbouring country. I have already noticed the accumulations of old alluvial detritus south of Eden; but they bear no comparison to the vast heaps of similar materials which cover, to an unknown depth, nearly all the tracts of low land bordering on the coast of Cumberland: and all the islands off the coast of Low Furness are exclusively composed of rounded masses of rock (sometimes many tons in weight,) brought down from the old Cumbrian and Lancashire chains, and imbedded in a kind of red alluvial loam derived from the degradation of the red sandstone *. In some parts of the coast the alluvial conglomerates are solidified, and only to be distinguished from the true conglomerates of the new red sandstone by the greater freshness of the imbedded pebbles: for the pebbles of the old conglomerates (however distinguishable in mineral structure,) have, in the regions I am describing, almost universally undergone a progress towards decay, and are sometimes hollow and entirely incoherent †.

Before I go on to the next section of this paper, it may be well briefly to recapitulate.

(1.) The red sandstone series above described appears among the last ramifications of the Eden, in a position decidedly unconformable to the carboniferous limestone ‡.

(2.) In its prolongation it rests upon the upper portion of the carboniferous

* The erratic blocks of the Cumbrian mountains are not confined to the places above indicated, but have been carried, in incredible abundance, over the plains of South Lancashire and Cheshire. They are also found, at a great elevation (for example, near the top of the pass from Macclesfield to Buxton), on the chain of hills which separates Cheshire and Derbyshire. I also found them last summer, though generally much diminished in size, on the flanks of the Denbighshire hills, above Oswestry. To what cause are we to attribute this drift of the Cumbrian rocks? Whatever it may have been, it must have acted *at a comparatively recent period*; for many of the travelled bowlders, though lying bare on the surface, are very little decomposed, and still ring under the hammer. The present condition of the Cumbrian valleys confirms the previous statement; for an examination of them leads us inevitably to two conclusions: 1st, that they were not formed by the erosion of the waters now flowing through them; 2ndly, that the causes by which they were brought into their present form must have ceased their action *at a comparatively recent period.* Every Cumbrian valley which contains a lake gives an independent proof of what is here asserted.

† Considered as mere mineral specimens, the conglomerates of the old red sandstone, in the North of England, have often a much newer appearance than those of the new red sandstone. This fact may be partly due to the cementing principle, and partly to the more indestructible nature of the imbedded pebbles of the old red conglomerates. Both in the South-west and North of England, the fragments of mountain limestone, which enter so largely into the new red conglomerates, are generally well preserved where the cementing principle is highly calcareous; but where the cement is siliceous, the limestone pebbles are, I believe, universally decomposing, and in some instances have almost disappeared.

‡ Plate XXV. fig. 2.

series; and, in the long range from Appleby to Maryport, there are few places where the two formations can be shown, by their dip or inclination, to be in an unconformable position.

(3.) At St. Bees Head it has apparently the same dip as the coal measures *. But in the same neighbourhood it is proved to pass obliquely over their outcrop; and, after overlapping the mountain limestone, to range along the flanks of the primary mountains †.

(4.) It overlies the carboniferous system of Low Furness, and reappears in the next promontory, as a conglomerate unconformable to the mountain limestone.

It offers, therefore, most obvious analogies to the new red sandstone series of many other parts of England. In one respect, however, it greatly differs from the overlying red sandstone of the great Bristol and Welsh coal fields; as its beds are, in a part of its range, not only parallel to the beds of the carboniferous series, but appear, through an intermediate sandstone, so nearly to pass into them, that it becomes extremely difficult to define the precise limits of the two formations.

§ 2. *On some detached Masses of the Carboniferous Series within the area of the New Red Sandstone.*

There may be three causes to account for the appearance of such masses: 1st, When the chain of Cross Fell was severed (by the great dislocation above noticed), from the carboniferous chain now forming the outskirts of the primary Cumbrian system, it seems probable (independently of direct evidence), that some large dislocated masses of rock would be left in the intervening area which is now generally covered with the new red sandstone. 2ndly, The red sandstone may, when first deposited, have been of a very irregular thickness, and in some places may have left the inferior rocks partially uncovered. 3rdly, The protruding masses of the older rocks may have been laid bare by the great denudations already mentioned. To one or more of these causes we may attribute the appearance of the detached portions of the carboniferous series I am about to notice.

The first example occurs near the middle of Broadfield (once a wild heathy tract of land, but now inclosed), about six miles due south of Carlisle, and about a mile and a half east-south-east of the village of Gatesgill. Close to the meeting of four roads, fine contorted masses of mountain limestone are exposed in three quarries, two on the east side of the Penrith road, and one

* Plate XXV. fig. 1.

† Plate XXV. fig. 5 & 6.

on the west*. In the two eastern quarries we have fine thick beds of mountain limestone, some dipping south-south-east, and others nearly perpendicular, surmounted by several impure beds, which will not burn to lime, and by about fifteen feet of gravel, tinged red with fragments of the new red sandstone. In the western quarry the dip is about north-north-east. At one end of it the limestone is more than twenty feet thick; but it thins off, at the other end, to about half that thickness. This mass is associated with a white freestone, and with an impure, ferruginous, encrinite limestone unfit for use. Some purple-coloured shale and siliceous gritstone, laid bare in a small excavation about half a mile south-west of these quarries, appear also to belong to the carboniferous series; but how far they are expanded over the plateau of Broadfield, it would be no easy matter to determine, in the present concealed state of the country. In the valleys of Ivegill and Raw Beck, to the south and east of Broadfield, there are, however, very fine escarpments of new red sandstone.

The next example is seen in Chalk Beck, about a mile north-east of Rosley, and three quarters of a mile above Chalk Foot. On the right bank of the rivulet there is an escarpment of limestone between 20 and 30 feet thick, surmounted by 30 or 40 feet of red diluvial gravel. Close to this escarpment are beds of new red sandstone, partly resting upon the limestone, and partly separated from it by thin beds of conglomerate containing angular fragments of limestone. In such a position it might easily be mistaken for a portion of the formation of magnesian limestone, especially as some of the beds are earthy and cellular; and all of them are yellow, and contain magnesia. It, however, on the whole, more resembles the dolomitic varieties of mountain limestone; and it dips slightly to east by south, while the nearest beds of red sandstone dip north-north-west. Moreover, it contains Orthoceratites, beautiful corals of the genus Caryophyllia, resembling species well known in the mountain limestone, and large Productæ, among which, if I mistake not, is the *Producta Scotica*; but it does not contain any characteristic fossil of the magnesian limestone formation. On these accounts I do not hesitate to class it with the outlying rocks of Broadfield, which are undoubtedly of the carboniferous order†.

The last instance which fell under my notice, of any outlying portion of

* The locality is defined on the county maps by the meeting of four roads,—from Gatesgill, from High Burnthwaite, from Burghthwaite, and from Itonfield.

† There may be some doubt whether the Chalk limestone be *within* the area of the new red sandstone, of which it is impossible to lay down the demarcation in a continuous line. There is, however, an outbreak of the red sandstone at Green quarry, about half a mile further up Chalk Beck.

the carboniferous rocks within the area of the new red sandstone, occurs near the village of Aketon, about four miles north of Wigton. Some of the neighbouring country is much covered by ancient turf bog and a peculiar sandy alluvion; but to the north of the village some beds of limestone and shale are laid bare on both sides of the road; and if I have not been misinformed, a bed of coal 16 inches thick was proved, by boring, to be associated with them, at a place called Moor Dyke, on the west side of the road. I mention these facts in the hopes of calling to them the attention of future observers; for I know of no place within the limits of the red sandstone, where a search for coal could be commenced with the same prospect of success. My knowledge of the central portions of that great area, within the basin of the Eden, which is chiefly covered by the new red sandstone, is, however, extremely limited. My examination of Cumberland was chiefly confined to the carboniferous rocks and the central cluster of mountains; and whenever, in making a traverse, I was led to the edge of the new red sandstone, I generally considered my immediate labours at an end.

§ 3. *On the successive Deposits which compose the New Red Sandstone Series, &c.*

The preceding details give a general notion of the distribution of the new red sandstone series within the basin of the Eden, and on a part of the coasts of Cumberland and Lancashire; but they give only a very inadequate indication of the structure and order of those great mineral masses of which it is composed. This information is, however, conveyed in a much more perfect manner by the coast section, from Parton to St. Bees Head, which I now proceed to describe*.

The rich coal field of Whitehaven, constituting that part of the carboniferous series which is superior to the millstone grit and mountain limestone, may be separated into two divisions, the upper containing the great *main* and *bannock bands*, the lower containing four or five workable beds, but of inferior quality. The united thickness of these two divisions is, perhaps, not less than two thousand feet; and from this estimate the carboniferous limestone and its associated beds are of course excluded. The upper beds are worked in a small field on the coast, immediately south of Workington; but in consequence of an enormous *upcast fault* they are thrown out, and the lower division is brought into the cliff, and occupies an extensive plateau stretching from Harrington to the hills north of Morresby, about two miles and a half from the harbour of Whitehaven. Near the crown of these hills (and about a mile from

* See Plate XXV. fig. 1.

the point where the accompanying section commences) another great fault, producing a *downcast* to the south-west, probably of not less than a thousand feet, once more brings in the upper rich division of the coal field. Unfortunately, however, between this *fault* and the village of Parton, the beds dip to the east; so that all those which are below the high-water mark necessarily crop out under the sea. The result is, that no one has been able to extract the coal, in consequence of the great quantity of sea water which finds its way through the beds along their planes of dip.

At Parton there are other considerable dislocations, not merely altering the relative level of the beds, but again producing a reversed dip, by which the whole series of coal measures, as well as all the overlying groups extending to St. Bees Head, are made to plunge to the south-west at a small angle of inclination. The successive strata, therefore, after this last inversion of dip, have their outcrop in the interior of the country; and the coal seams are perfectly protected from the sea water by the impervious overlying beds of shale.

Such is the position of the submarine portion of the coal field of Whitehaven; and it does not seem possible to assign any limit to the works that may there be conducted under the sea in the direction of the dip. But it is foreign to my purpose to give any description of these works, as the preceding remarks are introduced for the sole purpose of explaining the nature of the base line on which the accompanying section is constructed*.

The north-eastern extremity of this section commences at Parton, among some broken and contorted beds. The confused ground extends about 150 yards, after which the beds acquire their regular south-western dip above described. Following the coast towards Whitehaven, we find the cliff composed of shale and sandstone, which, after being continued several hundred yards, is suddenly cut off by a *downcast fault*, of 24 fathoms, to the south-west†. From this point to the north end of Whitehaven, we find an uninterrupted rock of coarse sandstone (resembling many well-known varieties of millstone grit), generally of a gray or brownish gray colour, but here and there with stains and streaks of red. Parts of the rock are of a very strong texture, and have been extensively quarried for the new piers at Whitehaven. It has also been cut through by the old tunnel between Whitehaven and Parton, as well as by a

* I owe the knowledge of most of these facts to my friends Messrs. Peile, of the Colliery Office, Whitehaven; and in a subsequent memoir on the carboniferous series of Cumberland (in which a description of the Whitehaven coal field will of course form an important part), Mr. W. Peile has promised to be my fellow-labourer.

† This is the second fault marked on the section.

new tunnel, now excavating for the purpose of a ready communication with the hills west of Dissington, where the main coal seam is about to be worked. Its structure is therefore very well exposed.

Close to the north end of Whitehaven comes in another fault, producing *a downcast* to the north-east, of eleven fathoms; but if we follow this fault into the interior, the quantity of dislocation produced by it is enormously increased. By this and two other faults, elevating the strata in the same direction, we may explain the high position of the quarry sandstone in the hills immediately south of the town. At Saltom, as is seen in the section, are two faults, producing downcasts in opposite directions: their joint effect is to bring the great sandstone once more to the level of the sea, after which it is continued nearly a mile in a lofty cliff; and its component beds are carried by their dip (with the interruption of one fault) in regular succession towards the base of St. Bees Head.

The general character of this sandstone is the same as in the tunnel cliff, north of Whitehaven; but it is of a much redder colour, contains many small ferruginous nodules, and in mineral character is perfectly identical with many portions of that peculiar red sandstone which separates the Yorkshire coal measures from the magnesian limestone. It is generally without any trace of fossils: the very extensive excavations carried on in it on both sides of Whitehaven, have, however, brought to light a few obscure impressions of Equiseta and Calamites. It makes, therefore, a very near approach to a true coal grit; and in the surveys hitherto published, as well as in the estimation of the coal viewers of the neighbourhood, it has, I believe, always been regarded as a true member of the coal measures.

Under Barrowmouth this sandstone is surmounted by a conglomerate, exactly like the magnesian conglomerates of our south-western coal fields, but only two or three feet in thickness. Its lower part is of a reddish colour, and contains, among other fragments, rolled masses of mountain limestone mixed with hydrate of iron. The upper parts of it have a calcareo-magnesian cement; and it is surmounted by, or rather graduates into, a yellow, foliated, cellular, magnesian limestone. This limestone is not well exposed at the sea-side, being almost buried under the overlying red marls; but some of its upper beds are mixed and striated with red ferruginous matter, and seem to pass into a singular, red, siliceous sandstone containing jasper and chalcedony. It is, however, extensively worked at Barrow and Preston How quarries, and shows in great perfection most of those peculiarities of structure which so well mark the formation. I do not know of any section where all its beds are exposed; but it probably never exceeds 60 feet in thickness. Of its relations to the coal

measures, there could not be a shadow of doubt, though there were no other section besides that on the coast; and in Croft Pit it has been sunk through into the lower sandstone and down to the *main* and *bannock* seams. Along with the other upper strata, it strikes across the peninsula of St. Bees Head, and is seen in Ben How quarry (near Green Bank farm), on the low road from St. Bees to Whitehaven, where it is made, by a remarkable *fault*, to abut against the lower red sandstone*. Beyond this point the yellow, cellular limestone beds do not appear; but the magnesian conglomerates are found to the south of the valley of St. Bees (at Parkhouse, and in the rivulet which runs down thence towards Linethwaite), forming the base of the new red sandstone group.

Over the preceding deposit of the coast section, come several feet of gray, thin-bedded, sandy marls, to which the red jaspideous bed, above noticed, appears to be subordinate. This sandy deposit is surmounted by alternating beds of unctuous, red marl and gypsum, amounting in thickness to eight or ten fathoms. The two substances are so mixed together, in some places, as not to be separable; but in other parts of the section (and especially in the higher and lower portions of it) the gypsum is found in strong beds, which have been much worked; and in one of the excavations was found a bed, about half an inch thick, composed of a nearly pure, earthy, semi-indurated carbonate of zinc. This fact deserves remarking, as carbonate of zinc occurs in considerable abundance in deposits on the Mendip Hills, nearly of the same age with those here described.

Lastly, the gypseous marls are surmounted by sandy marls and micaceous, slaty sandstone, rising to a considerable height in the red precipice of St. Bees Head; and these are overlaid by a great, thick-bedded freestone, which in some places loses the lines of stratification, and decomposes into rude, grotesque, castellated forms. These upper rocks are identical with the finest specimens of the new red sandstone of Cheshire and Lancashire, of Low Furness, Appleby and Carlisle, and may be regarded as one of the most characteristic exhibitions of the formation to be seen in our island.

The several beds entering into the structure of St. Bees Head, are carried by their south-western dip, and by a downcast fault, one after the other under the sea; and no superior formation is visible on any part of the neighbouring coast. The "upper red marl and gypsum," completing our red sandstone series up to the lower lias marls, are therefore wanting, either having been washed away by those causes which have produced the present deep indentations of the coast, or being, perhaps, buried under the waters of the western sea.

* See Plate XXV. fig. 4.

So far the account of the accompanying section, and of the successive groups of rocks overlying the Whitehaven coal field, has been purely descriptive, and unmixed with any hypothesis. The facts themselves contain, however, their own interpretation. I have already stated that the lower sandstone, overlying the Whitehaven coal field, resembled in structure the lower sandstone immediately overlying the great Yorkshire and Durham coal fields. The former contains, though very sparingly, impressions of Equiseta and Calamites; and so does the latter, as I have now ascertained, though I was unacquainted with the fact at the time the detailed account of the structure of the magnesian limestone series was published in a former part of our Transactions*.

Again, though the "lower red sandstone" of Yorkshire and Durham appears, in some cases, to graduate into the coal measures (on which account it was classified with them by Mr. Smith in his geological map of Yorkshire); yet, when considered on a great scale, it is unconformable to them, and on that account was separated from them and arranged, in the paper just quoted, as the lowest member of the new red sandstone group. In the same manner, in the coast section above described, the lower overlying sandstone appears to be conformable to, and to graduate into, the coal measures of Whitehaven. But, during many excursions in that neighbourhood, I have traced it from the sea-side to the interior of the country, to the top of the hills above Dissington, over the summit of Whillimoor, and to the crest of the hills overhanging Arlecdon; and thus ascertained that it spreads over the edges of the coal measures, and that, when considered in its whole extent, it is, as far as regards the position of its lower surface, perfectly analogous to the "lower red sandstone" of Yorkshire and Durham.

But the analogies do not end here. It is proved by several of the sections published in a former part of our Transactions†, that the "lower red sandstone" in certain parts of Yorkshire had undergone considerable movements, and been exposed to considerable degradations, before the deposition of the magnesian conglomerate and magnesian limestone: for they are here and there seen resting on its inclined edges, while in other places (for example at Pontefract, in many parts of the County of Durham, and on the coast of Northumberland), the "lower red sandstone" and magnesian limestone graduate insensibly into each other, without any break of continuity whatsoever‡. Now we meet with precisely the same accidents of position in the

* Vol. iii. p. 37. *et seq.* Very fine impressions of Equiseta or Calamites have been found in the "lower red sandstone" of Hooton-Lovett in Yorkshire.

† Geological Transactions, Second Series, vol. iii. Plate VI. figg. 3. 4. 5. 6.

‡ Ibid., vol. iii. p. 67.

neighbourhood of Whitehaven: for in following the overlying deposits into the interior of the coal field, we find many traces of magnesian conglomerates, with rolled masses of mountain limestone, in every respect identical with those of the coast section (for example, at Gilgaron, near Arlecdon, at Sand Closes, &c.); and we have the clearest proof that the lower red sandstone had been exposed to considerable degradations, and scooped out into great hollows before the conglomerates, which form the base of the magnesian limestone, were first accumulated. It follows, therefore, that the "lower red sandstone" overlying the Yorkshire and Durham coal fields, and the lower red sandstone of Cumberland, are identical in their structure, their relations, their fossils, and in all the accidents to which they were exposed during their deposition. We may therefore conclude that they are true geological equivalents; that they are probably on the parallel of, at least, the lower portion of the *grès des Vosges*; and that they are unquestionably the equivalents of the *rothe todte liegende* overlying the coal series at the southern extremity of the Hartz mountain.

The magnesian conglomerates, described in the previous details of this paper, cannot be classed with the lower red sandstone, to which they are sometimes unconformable; but they graduate into, and form an integral part of, the magnesian limestone, sometimes appearing entirely to replace it.

The magnesian limestone of the coast section is evidently on the exact parallel of the magnesian limestone of Nottinghamshire, Yorkshire, and Durham, though not developed on so large a scale, or separable into the same number of minute subdivisions. It is not coextensive with the upper division of the overlying sandstone series; but it *may* exist in many places, under the great heaps of transported matter; and it breaks out, as above stated, in a very characteristic form, from beneath the new red sandstone of Low Furness, in a deep valley near the village of Stank*. With this exception, I have never seen it beyond the promontory of St. Bees Head, in any place within the limits of the range of country above described.

The red marl and gypsum under St. Bees Head are very nearly on the parallel of the "*lower red marl and gypsum*" of the Yorkshire series†; and the red sandstone of St. Bees Head is unquestionably the exact equivalent of the upper red sandstone of that series. The "upper red marl and gypsum"

* See Plate XXV. fig. 7.

† There are in Yorkshire two deposits of red gypseous marls under the great mass of the upper new red sandstone; one under, the other over the thin-bedded limestone of Ferrybridge. With either of these the gypseous marls of St. Bees Head may be brought into comparison, as the Ferrybridge limestone is not seen in Cumberland.

(probably on the parallel of the *marnes irrisées* and the *keuper* of France and Germany) do not appear in the coast section, for reasons already stated.

From all these facts, I conclude that the *series* of deposits overlying the Cumberland coal fields is, as far as it goes, perfectly analogous to the corresponding series of Yorkshire and Durham, as described in a former paper.

Nor need we be surprised at this analogy, when we consider the almost perfect agreement of the great groups of the new red sandstone series in England and central Germany. I need not repeat the evidence on which this conclusion rests; but I may add, that it is even more complete than I supposed at the time the former memoir was published. Three obscure corals, found in our magnesian limestone, had already been figured by Mr. Goldfuss under the generic name of Gorgonia*; and on referring to his account of the localities from which his specimens were derived, it will be seen that they come from the magnesian limestone formation of Mansfeld. Nor has this conclusion been drawn from the mere resemblance of the figures; for both the British and German specimens have been examined by that accomplished naturalist, and the fossils found to be specifically identical, as he has himself informed me. This fact alone, to which, however, a thousand others might be added, is a sufficient reply to the assertions of some modern writers, who have ventured to affirm that organic remains are of no value in determining the contemporaneity of distant formations.

In our south-western coal fields the deposits immediately overlying the carboniferous rocks are subdivided into three principal groups: the lowest composed chiefly of conglomerate, with a calcareo-magnesian cement; the middle group of red and variegated sandstone; and the highest of red and variegated gypseous marls. I think it at least probable that the conglomerates of the Bristol coal fields are on the exact parallel of the magnesian conglomerates described in this paper; from which it follows that the Bristol conglomerates, as well as those in the valleys of Devonshire (if they be all of the same age), are the true representatives of the magnesian limestone, and not of the *rothe todte liegende.*

I ventured to express this opinion in a former paper†; and it is greatly confirmed by the facts here stated, as well as by some other facts which fell under my observation last summer (1831), while crossing over one of the coal formations of Shropshire. About six or eight miles south-west of Shrewsbury there is a small coal field, stretching at the base of a greywacké chain from

* See Goldfuss, tab. vii. fig. 1; tab. xxxvi. fig. 1; and tab. x. fig. 1; *Gorgonia dubia, G. anceps, G. infundibuliformis*; and compare them with Geological Transactions, Second Series, vol. iii. p. 120; and Plate XII. figg. 5. 6. 7. 8.

† Geological Transactions, Second Series, vol. iii. p. 122.

Pontesford towards Westbury, and surmounted by a series of deposits connected with the group of the new red sandstone. The order of succession, as laid bare by a deep cut for the road near Aldbury, is as follows: 1st, Coal measures. 2ndly, Coarse reddish sandstone, in character intermediate between a coarse coal grit and a true red or variegated sandstone. 3rdly, A very fine magnesian conglomerate, forming a distinct range of hills by Cardeston, Rownton, and Adenbury, and in mineral structure like the Bristol and Devonshire conglomerates*. 4thly, Red and variegated sandstone descending into the great plain of Shropshire, and of unknown thickness. Here, therefore, the section is more complete than at Bristol, and is perfectly analogous to the Cumberland coast section, with this exception, that the conglomerate is developed at the entire expense of the magnesian limestone. The conclusion naturally deduced from this section is the same as that at which I before arrived—viz. that the magnesian conglomerates do not represent the *rothe todte liegende*, but a part of the next superior division—the magnesian limestone, or *zechstein*.

In comparing the Bristol and Exeter conglomerates with the *rothe todte liegende*, our geologists made use of the best evidence with which they were acquainted. But the new red sandstone group is now better understood; and in future comparisons with Continental deposits of the same age, we should use, as our types, those sections which are most complete, instead of the Bristol or Exeter overlying groups, in which more than one half the series is absolutely wanting. Nor is any assistance to be derived from the accidental presence of porphyry pebbles; in as much as they occur in the Shropshire conglomerates, as well as in those of Exeter, and are in truth of no value in determining the relative age of any secondary rock.

It must, however, be allowed that a considerable part of our difficulties have arisen from the ill-defined language of some of the German geologists. The term *rothe todte liegende* has probably been often applied to conglomerates of the same age with our magnesian conglomerates. It originally designated certain, coarse, red sandstones overlying the coal measures of the Hartz, which, after a personal examination of them, I believe to be the exact equivalents of the "lower red sandstone" above described. In the late works of Mr. Hoffmann the same term is applied to a red sandstone under the coal measures of Wettin, and therefore on the parallel either of some of our lowest red coal grits, or perhaps of our old red sandstone.

* The condition of the pebbles imbedded in this conglomerate is very remarkable. Some of the mountain limestone pebbles retain their mineral structure and characteristic fossils; others are so altered as hardly to be distinguishable; some having become granular, and some perfectly pulverulent. See a previous note, p. 390.

It only remains for me to notice the importance of the *lower red sandstone* in another point of view, entirely distinct from the former. All who have written on our south-western coal fields, have noticed the total break of continuity between their component strata and the overlying series: and in the beautiful illustrations accompanying the paper of Dr. Buckland and Mr. Conybeare*, it is impossible to point out the highest members of the inclined coal measures, in as much as an indefinite number of them *may* possibly be buried under the superior horizontal deposits. In Shropshire there is, I think, no such break of continuity, the gap being filled up by the *lower red sandstone*. Again, though the lower red sandstone of Yorkshire is, on a great scale, unconformable to the coal measures, and ought, on that account, to be considered as the base of the new red sandstone series; yet there are places in that county, where, for twenty miles together, there is no trace of any want of conformity; and the lower red sandstone (containing, as already stated, a few coal plants) forms a true connecting link between the highest coal grits and the group of the new red sandstone†.

Considering, then, that the red sandstone group sometimes forms a passage into the coal series,—that the fossils of the magnesian limestone are very nearly the same generically, and sometimes specifically, with the fossils of the carboniferous limestone‡,—that the grits of the coal measures in the North of England are not unusually of a red colour,—that on the confines of Scotland the lowest division of these coal grits alternates with red gypseous marls, and passes downwards into beds of red sandstone and red shale, nearly, if not exactly, on the parallel of the old red sandstone§,—considering all this, I think that the phænomena exhibited by our lower secondary deposits lend some support to a classification now generally adopted in Germany, which regards the whole carboniferous group but as an integral part of a great formation of red sandstone, commencing with the old, and ending with the new red sandstone series. The zoological argument certainly gives some consistency to this arrangement.

I do not, however, mean to deny the full propriety of the classification of the same great groups, now adopted by English geologists. It is good, because founded in nature; and each country ought to be described without any accommodating hypothesis, according to the type after which it has been

* Geological Transactions, Second Series, vol. i. p. 211.

† Ibid. vol. iii. p. 57. No. 5. ‡ Ibid. p. 119.

§ The description in the text was derived from phænomena, observed in 1830, in the valley of the Tweed. The gradual passage of the coal measures into the old red sandstone is still more strikingly exhibited on the coast of Scotland, north-west of St. Abb's Head.

moulded. But in comparing the unconnected deposits of remote countries, we must act on an opposite principle; learning to suppress all local phænomena, and to seize on those only which are coextensive with the objects we attempt to classify. In this general view the arrangement of the red sandstone and carboniferous series in one great group, is perhaps the best fitted to the present state of our knowledge.

§4. *General Comparison of the Red Sandstone Series of Scotland and England.*

It has been shown by Mr. Murchison and myself, that in the Isle of Arran a carboniferous series is interpolated between two enormous masses of red sandstone and conglomerate; and that the whole group passes, in the ascending order, into a formation of red sandstone, which *may represent* either one of the red, sterile parts of the Scotch carboniferous series, or the lowest division of the new red sandstone*. It is almost impossible to ascertain the precise limit of this upper red sandstone of the Isle of Arran: but the best way of approximating to it would be to trace the old red sandstone group from the south flank of the Grampians to the west coast of Scotland; and from thence to follow the red sandstone series to the coasts of Ayrshire. By the help of such an examination (a desideratum in Scottish geology), we might perhaps establish such analogies as would enable us to determine the exact upper limit of the Arran section.

I consider it now established beyond doubt, that the great masses of red sandstone and conglomerate which fringe the Highland coasts, and range, on the south flank of the Grampians, from one side of Scotland to the other, belong almost exclusively to the old red sandstone. The large development of the bituminous schist of Caithness has thrown some unnecessary difficulties in the way of this conclusion. It alternates, however, with the old red conglomerates to their base, and cannot be separated from them†; it is overlaid by a red sandstone decidedly of older character than any variety of the new red and variegated group ever seen in other parts of Great Britain; it contains a suite of fossils peculiar to itself; not, as far as is known, interchanging a single species with the magnesian limestone; it is represented (and by no means in an unusual form) on the south flank of the Grampians by a series of thin-bedded strata, placed by Mr. Lyell even lower than the old red sandstone‡: and, lastly, the remains of fish have been found by Dr. Fleming in groups of slaty sandstone, which, though superior (like most of the Caithness schists), to the lowest old red conglomerates, are inferior to the true carboni-

* Geological Transactions, Second Series, vol. iii. p. 21; and Plate III.

† Ibid. pp. 140. 157. 158.

‡ Ibid. vol. ii. Plate X.

ferous formations of Fifeshire. I conclude, therefore, that the true position of the ichthyolites of Caithness is out of all doubt, and adhere, with very slight modifications, to the classification published by Mr. Murchison and myself*.

By way of conclusion, I may add, that the anomalies at which I have pointed, in different parts of this paper, and the difficulties they throw in the way of any universal classification, can be no matter of surprise. The great cause for wonder is, that among such vast and rude, mechanical operations of nature, we should be able to trace even the approximate elements of order. Whatever may be hereafter decided about the general grouping of the coal measures, the near coincidence of even the minute mineralogical subdivisions of the new red sandstone series in the North of England and central Germany, and the general correspondence of their fossils, must be regarded as one of the most satisfactory conclusions of secondary geology.

POSTSCRIPT.

Cambridge, August 7, 1835.

In consequence of the long delay in printing our Transactions, memoirs must sometimes appear which, at the time of their publication, do not express correctly the opinions of the respective authors. The preceding paper is published (with the exception of verbal corrections and the addition of the short notes) as it was read to the Society. Had the concluding remarks been written now, they would have been considerably modified.

I have taken for granted that the Exeter conglomerates, and those overlying our south-western coal fields, are of the same age. Mr. De la Beche has, I believe, ascertained, since this paper was read, that the former are older than the latter. Hence, the remarks intended to show that the magnesian conglomerates (*e. g.* those of the Bristol coal fields, the flanks of the Mendip Hills, &c.) were not the equivalents of the *rothe todte liegende*, cannot be applied to the conglomerates of Exeter, at least without some modification. The Exeter conglomerates *may*, then, be equivalents of the *upper part* of that sandstone which, in the North of England, fills up the chasm between the coal measures and the group of the new red sandstone. There is, however, in all the sections of Somersetshire, Devonshire, and South Wales, a want of continuity in these formations. Their position is perfectly discordant, so that it is physically impossible the successive deposits should be complete: something is wanting, which is supplied by the uninterrupted sections in the North of England†.

* Geological Transactions, Second Series, vol. iii. p. 157.

† Precisely in the same way, the sections in the North of England, connecting the old red sandstone and the slate rocks, are not continuous; and there is just the same break in Denbighshire

The discussion on the age of the Caithness schists might now be considered unnecessary; but when the paper was read, there were many members of the Society who were disposed to identify them with the ichthyolites of Mansfeld. The question is now set at rest by the generic and specific characters of the Caithness fossils, and by the discovery of fossil fish in the old red sandstone of Herefordshire, identical with specimens found in the old red sandstone of Scotland.

Were I to make any change in the Caithness section, published by Mr. Murchison and myself*, I should alter the colour of the sandstone of Dunnet Head, and make it of one tint with the lower conglomerates; thus including the highest beds of the series in the old red sandstone. The formation would then have three divisions, which might be respectively compared with the three divisions of the Herefordshire sandstone, first given by Dr. Buckland and Mr. Conybeare; and the *ichthyolites* of Caithness would then come on the same parallel with the *cornstones* of Herefordshire.

If such a comparison be considered as too refined for the evidence on which it rests, I may at least assert, that the words "*newer red sandstone,*" placed under the colour representing the group of Dunnet Head, tend only to mislead the reader, and do not correctly represent our opinions at the time the section was published†. By these words, English geologists have generally designated deposits of the age of the upper sandstone of St. Bees Head, with which it was never our intention to bring the rocks of Dunnet Head into comparison‡. It is true, that the upper limit of these rocks must remain in some measure ambiguous; but I have now little doubt that the whole of them ought to be classed with the old red sandstone.

The relations of the red sandstone group of Shropshire to the carboniferous series have been described during the past year in great detail by Mr. Murchison; and I believe his views agree perfectly with what is stated above (pp. 399, 400.). I had few details to offer, and only alluded to the Shropshire formations for the purpose of confirming conclusions drawn from certain phænomena in the North of England.

and Flintshire. How many terms of the series are wanting it is impossible to tell without more evidence; but this evidence is given in the Shropshire and Herefordshire sections described by Mr. Murchison.

* Geological Transactions, Second Series, vol. iii. Plate XIV. fig. 2.

† I am the more anxious to make this correction, because Mr. Conybeare has adopted and extended this error in his Memoir on the Progress of Geological Science, published in the first volume of the Reports of the British Association for the Advancement of Science.

‡ Geological Transactions, Second Series, vol. iii. pp. 157, 158.

APPENDIX.

On the Demarcation of the New Red Sandstone Group, described in the preceding Memoir.

The northern line of demarcation, commencing near Brough and ending on the Scotch border, has been already noticed (*supra*, p. 384, *note*). The remaining line may be traced as follows. Commencing, as before, at the top of the flat lands near the bifurcation of the Belah, the line may be drawn a little south of the left bank of the river, so as to leave out Caber. It then turns, about south by west, till it just touches Winton, from which it ranges a little to the west of Hartley, just under the road from Hartley to Naitby, which place it incloses within the area of the red sandstone; thence, crossing the river, it enters the north end of Wharton Park, and ranging nearly due north, passes along the brow of the hill just above Kirkby Stephen. The range then appears to be about north-west for more than a mile, when the line makes a bend, passing the rivulet about half a mile south of Soulby; thence to the rivulet a little north of Crosby, from which a curve line may be drawn skirting the high lands, so as to pass a little east of Musgrave; afterwards nearly parallel to the Eden, so as to pass about a quarter of a mile south of Warcop Bridge, north of Birks Chapel; half a mile south of Little Ormshead; and from the last-mentioned point to the rivulet just above Hoff. The line is then nearly defined by the left bank of the rivulet, and passes to the north-west just above Colby, which it incloses.

Part of the preceding line is imaginary, the country being covered by enormous masses of red diluvial gravel. But the conglomerates are seen at Belah Bridge, in the river under Winton, at Naitby and Kirkby Stephen, and in the river above Soulby. Again, the red sandstone is seen on both sides of the river near Warcop; and the conglomerates break out in the rivulet south of Little Ormshead, and at Hoff and Burrels.

From Colby the line runs down close to the left bank of the Eden, under Beuley Castle; thence, through Bolton to the rivulet a little south of Walk Mill; afterwards nearly parallel to the rivulet, and a little to the west of its left bank; thence, skirting the low lands, to a point about half a mile south of Cliburne. The remaining demarcation to the Eamont, is very obscure; but it passes by Clifton Dykes, and under Brougham Hall, into the alluvial flat of the river, and then enters Cumberland*.

For many miles, after it enters Cumberland, the line of demarcation is very ill defined. To the east of the Petteril is a lofty ridge of new red sandstone hills, commencing with Penrith Beacon. But on the road from Penrith to Hutton and Hesket Newmarket, we pass a very doubtful country, which has always been coloured as new red sandstone. Some of the red sandstones in that district (for example, at Catterlen, Hutton Park, &c.,) appeared to me, however, (when I ex-

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* The area inclosed by the line above described is extremely covered with red gravel, formed, in part, by the breaking up of the new red sandstone. Within the same area are also some places where the new red sandstone has been washed off. Thus, near Warcop, there is in the bed of the river an inclined micaceous red grit, probably belonging to the carboniferous series. Some very remarkable red gritstones, associated with a magnesian limestone, are found on the hills west of Soulby, and are clearly a part of the carboniferous system. I do not think the lower division of the new red sandstone is found in this district; though I ought not to make the assertion with much confidence, having never examined it since the year 1823.

amined the district in 1823,) more to resemble the ferruginous coal grits, or the lower red sandstone; and I think it probable (after what has been stated above respecting Broadfield, *supra*, pp. 391, 392,) that a spur of the older rocks, between the Petteril and the Caldew, encroaches considerably on the line I am describing. I throw this out as a mere conjecture, confirmed, however, by the fact, that inclined beds of a hard red gritstone are also found along the Petteril, at least as far north as the Broadfield limestone.

Passing, then, this doubtful tract, we find characteristic beds of new red sandstone between Macey Bank and Ivegill; and thence, south of Highhead Castle to the banks of Raw Beck, and down both sides of that rivulet for more than a mile. Here, again, the demarcation is not only obscure in many places from the want of good sections; but difficult also from the appearance of lower grits, of a red colour ("lower red sandstone"?), which break out in both the above-mentioned rivulets.

No rock is visible for some way west of Raw Beck; but an imaginary boundary may be drawn to the Caldew, a little south of Rose Bridge, and thence to Green Quarry, a little south of the Chalk limestone above described (*supra*, p. 392). From that quarry the line sweeps round nearly by Howrigg, Height, Brackenthwaite, Cragg Houses, and Tracing Tree (almost inclosing a remarkable dislocated coal field of Rosley, now nearly deserted). From Tracing Tree it passes through a wood, a little above the confluence of Silver Gill with the rivulet, and thence under Church Hill, and on the north side of Islekirk to Parson Bridge; from whence it may be traced near Cross Hill, a little above Bridge Mill, and close to Low Blaithwaite; from which place the line sweeps to the south-west a quarter of a mile south of Elfield, and more than half a mile above Crook Dyke Mill; and so after crossing the river in a direction about south-south-west, it turns west, ranging a little north of the Leesrigg road, through the hill above King Gate, along the south side of Brayton Hall Park, under the village of Aspatria, under Hayton, a little south of the road from Hayton to Allerby, just under Crosby; thence deflecting to the north-west, it passes north of Birkby, and down by the right bank of the Ellen to the sea at Maryport.

We may pass over the coast from Maryport to St. Bees Head, as it is either occupied by the coal measures, or by the "lower red sandstone," in places already described. Across St. Bees Head the range is defined by quarries, ending (as above stated) at Ben How*. On crossing the valley, it reappears in Walton Wood, just above Linethwaite, and thence passes just under Bank End, and at the base of an escarpment, from which it descends between Gill Foot and How Bank; and, inclosing Orgill, it disappears in the alluvial plain of Egremont.

Beyond this plain the line appears to range nearly east and west from New House to Grange; and from a quarry near the latter place it strikes about south-south-east into the valley of Kirk Beck. It crosses above the mill, and then ranges above Head of Hail and Hall Garth to the north end of Cold Fell near Side; from whence it descends into the valley of the Calder, in a direction about south-south-east. It crosses below Thornholm, and then ranges east-south-east on the way to Farmary, and is exposed in quarries at the hill-top. It then strikes across the Gill, and is laid bare about a quarter of a mile above Hurrel Barrow; thence it ranges through Blaing Fell, leaving Lockray and Whinray to the east, just touching Bank House, and forming the whole escarpment of the hill above Gosforth.

We have no regular escarpment of the formation on the Cumberland coast south of Gosforth; but the rock is seen at the following places: Drig Cross, west of Gosforth; Brandreth Scar and

* The range of "the lower red sandstone" over the coal field, as well as certain outliers of the new red sandstone, will be given in a subsequent paper.

Codlin Rock, two reefs to the south of Ravenglass, only seen at low water; on the Cross House estate, half a mile north of Bootle; and, lastly, in wells and other excavations at Mopus, Hise Moor, Well Bank, and Old Highton, all in the same neighbourhood, and on the north side of the Bootle rivulet.

Crossing the estuary of the Duddon to the limestone of Roan Head, we find the superior rocks concealed under blown sand; but the new red sandstone breaks out south of Wet Flats, and may be traced by Little Mill, Billing Coat, and Newton; and thence by Bousfield, Stank, and Hole Beck. Beyond the last-mentioned place everything is buried under alluvial accumulations to the sea-side; but at low water the red sandstone is seen just to the north of Rampside. It appears also at the north point of Old Barrow Island.

In the Cartmel promontory the new red conglomerates appear at Rougham Point, west of Humphrey Head; and the red sandstone is said to have been reached by boring between Cannon Winder and Ravend's Winder, and close to Lower Hosker.

By help of the preceding notice, the demarcation of the new red sandstone may be laid down on the large county maps with a near approach to accuracy. Had the Ordnance maps of the northern counties been published, such details would have been perfectly useless, as the information would have been more correctly conveyed by a superficial colour, than by any verbal description.

VII.—*On a portion of Dukhun, East Indies.*

By Lieutenant-Colonel W. H. SYKES, F.R.S. F.G.S. F.L.S.

[Read January 23, 1833.]

MY personal observation of Dukhun (Deccan) and Konkun (Concan) * is not confined to the boundaries laid down in the following geological memoir; but as the rock and mineral specimens remaining at present in my possession are from Dukhun only, I have not thought it proper to extend my details beyond the limits I here prescribe to myself, although I might venture to do so from notes taken at different periods, without exposing my accuracy to question. I will, however, in closing this paper, offer a few observations on the trap and other formations of India; the amazing extent of the former not appearing to have been appreciated hitherto in European geological works.

Boundaries.

My tract † is bounded on the west by the range of mountains usually denominated by Europeans the "Ghàts", from a misinterpretation of the term *ghàt*, which simply means a pass, the proper name of this range being the "Syhadree"; on the north by the Mool river, as far as Rahooreh; on the east by a direct line from Rahooreh to the city of Ahmednuggur, and subsequently on the north-east by the Seena river until its junction with the Beema river below Mundroop; on the south-east by a line from Mundroop to the celebrated city of Beejapoor; on the south by a line from Beejapoor to the town of Meeruj; and from this place the boundary in the south-west is the Kristna and Quina rivers, to the hill fort of Wassota, situated in the Ghàts. The western boundary line extends, as the crow flies, about 144 miles; the northern 72 miles; eastern and north-eastern 159 miles; south-eastern 41 miles; southern 80 miles; and south-western 88 miles. Agreeably to observations made by myself and the officers of the revenue survey in

* With respect to the pronunciation of native words, the "*u*" is the *u* in "*hut*," and the "*a*" the *a* in "*all*."

† See Map, Plate XXVI.

Dukhun, the tract lies between the parallels of north latitude 16° 45′ and 19° 27′, and east longitude 73° 30′ and 75° 53′, and, roughly calculated, may be said to comprise an area of about 26,000 square miles.

Stratification.

Previously to entering into descriptive details, I will state, in a few words, that the whole of the country comprised within my boundaries is composed of distinctly stratified trap rocks, without the intervention of the rocks of any other formation. Whether at the level of the sea, or at the elevation of 4500 feet, in all and every part, beds of basalt and amygdaloid are found alternating, whose superior and inferior planes preserve a striking parallelism to each other, and, as far as the eye can judge, to the horizon. Barometrical measurements and the course of rivers indicate a declination of the country to the east-south-east and south-east. From the town of Goreh, latitude 19°·03 and longitude 74°·05, on the Goreh river, following a mean course for the river until it falls into the Beema, and subsequently, continuing a mean course for the Beema until its junction with the Seena river, the distance is about 200 miles, and the declination 671 feet: there may therefore be a trifling dip of the strata; but as a succession of low terraces occur in that distance, the apparent horizontal position of the strata may be unaffected by the above difference of level.

Dr. MacCulloch, describing the overlying or trap rocks, says, "these masses are generally irregular, but sometimes bear indistinct marks of stratification *." As Dr. MacCulloch's language implies the *rare occurrence* of stratification, instead of its being a distinctive feature, at least of the Indian branch of the trap family, I deem it necessary to quote the few authors who have written on Indian geology, in confirmation of the fact I have stated †.

* Classification of Rocks, p. 466.

† "These mountains (the Vindhya range), like every other in Malwa, appear to be distinctly stratified, consisting of alternate, horizontal beds of basalt or trap and amygdaloid. Fourteen of these beds may in general be reckoned, the thinnest at the top, and rapidly increasing in thickness as they lower in position, the basalt stratum at the bottom being about 200 feet thick." Again, at page 327, he says: "In the upper plains of Malwa every point of view presents the same uniform and distinctly streaked appearance noticed in the Vindhya range."—*Captain Dangerfield, in Geological Notices of Malwa*, in Appendix No. 2. to Sir John Malcolm's Central India, pp. 322, 327.

Dr. Voysey, in a paper on the Geological and Mineralogical Structure of the vicinity of Nagpoor, says: "From the summit of the hill of Sitabaldi the difference in the outline of the rocks eastward is very perceptible. The *flattened summits* and *long flat outline*, with the numerous gaps of the trap hills, are exchanged for the ridgy, peaked, sharp outline of the primary rocks."—*Physical Class of the Asiatic Researches*, p. 127.

In a second paper in the same work, on some petrified shells in the Gawelghur range of trap

Ghàts.

The Dukhun rises, by a succession of terraces or steps, very abruptly from the Konkun*. Its valleys and table-lands have a mean elevation above the sea of about 1800 feet. The Konkun is a long strip of land from thirty to fifty miles in breadth, lying between the Ghàts and the sea; the mean elevation of this strip is less than 100 feet; but it is bristled with isolated hills, or short ranges, some of which attain an elevation equalling that of the Ghàts. Numerous shoulders or salient angles are thrown out from the Ghàts from the western or Konkun side, and by means of these the ascent to Dukhun is effected; with what difficulty, will be understood when I state that the military road of communication between Bombay and Poona, up the Bore Ghàt, rises nearly 600 feet in a mile. The western portion of my tract along the crest of the Ghàts is exceedingly strong: spurs of different lengths extend from the main range to the eastward and south-east, leaving many narrow tortuous valleys between them, some of which have the character of gigantic cracks or fissures; other valleys, although occurring less frequently, when looked at from the neighbouring ranges, appear as flat and smooth as a billiard-table, even to the crest of the Ghàts, but when traversed are found to be cut up by numerous narrow and deep ravines†. Stupendous scarps, fearful chasms, numerous waterfalls, dense forests, and perennial verdure, complete the majesty and romantic interest of the vicinity of the Ghàts. As the spurs extend to the east and south-east they diminish in height, until they disappear on approaching the open plains in my eastern limits, between the Beema and Seena rivers. The area of the table-land on their summit often exceeds that of the valley between them; such is the case with the spur bordering the left bank of the Beema river for forty miles from its source, occupying, in fact, the whole country between the sources of the Beema and Goreh rivers. The spurs are rarely tabular for their whole length, but narrow occasionally into ridges capped with compact basalt, and subsequently expand into extensive table-lands. The spur originating in the hill fort of Hurreechundurghur affords a good example. The fort is about eighteen miles in circumference: on the east it presents a salient

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mountains, extending for 165 miles along the left bank of the Tapty river, from its source to the city of Boorhanpoor, he describes the principal part of the range as formed of "compact basalt "very much resembling that of the Giant's Causeway. It is found columnar in many places, and "at Gawelghur it appears *stratified*; the summits of several ravines presenting a continued stratum "of many thousand yards in length."—*Physical Class of the Asiatic Researches*, p. 189.

* See Plate XXVIII.

† The valley of the Malsej Ghàt, for instance.

angle to the neighbouring mountain; absolute contact, however, only commences at about 400 feet from the top of the scarp, leaving a gap and an extremely narrow ridge, over which lies a difficult footpath of communication between the valley of the Malsej Ghàt and that of the Mool river. The spur then widens; some lateral ramifications shoot out, on one of which is situated the fort of Koonjurghur; at the Brahmun Wareh pass it narrows considerably, but not into a ridge; it subsequently expands into the extensive and well-peopled table-land of Kanoor and Parneir, twenty-four miles long by twenty broad, having diminished in height, by a succession of steps, from 3894 feet in Hurreechundurghur to 2866 at Brahmun Wareh, 2474 at Parneir, and 2133 on the terrace of Ahmednuggur. From Ahmednuggur the spur bends southward until it is finally lost in the neighbourhood of Sholapoor. It is, in fact, the margin of a great plateau, which has a mean elevation of about 300 feet above the valley of the Godavery river, and over which the rivers Goreh, Beema, Seena, &c., take their course. The basaltic caps of the ridges appear more or less columnar, from numerous vertical fissures; the weathering of these exposed rocks produces pillars, spires, towers, houses, and other forms of works of art*. Another feature of these spurs is the occasional occurrence on their table-lands of small hummocks or conical hills with a truncated apex. Dr. Voysey† mentions "groups of flattened summits and "isolated conoidal frustra" in the Gawelghur trap mountains.

One of the longest of the spurs originates in the Ghàts north-west of Satarah, and runs nearly east-south-east, about 110 miles, towards Punderpoor.

The spur immediately south of Poona, on the ramifications of which are situated the formidable fortresses of Singhur (4162 feet), Poorundhur (4472 feet), and Wuzeerghur, adjoining Poorhundhur (at nearly the same elevation), has an extent of ninety-five miles. The accompanying section, Plate XXVIII. fig. 2. represents this spur.

Valleys.

Much having been said respecting valleys of excavation, I think it may be acceptable to offer a few observations on the valleys between the spurs. I shall describe only those that present the greatest contrasts to each other.

Valley of the Mota River.—The valley of the Mota river, south of Poona, originating in a mass of hills on the edge of the Ghàts, is so exceedingly narrow, that for some miles the bases of the opposite hills frequently touch each other, leaving, at intervals, little horizontal plots, of a pistol-shot in width. These plots occur in terraces, on lower levels as they extend eastward.

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* See Plate XXVIII. fig. 1. and 2. on the Konkun; and Plate XXVII. fig. 1.

† Physical Class, Asiatic Researches, p. 189.

Vale of the Under.—The valley of the Under river, north-west of Poona, presents a perfect contrast to the last. It is level for twenty miles, running east and west to the very edge of the Ghàts; and a person can stand at the head of the valley upon the brink of a scarp rising almost from the Konkun. Here, at the source of the river, it is nearly six miles wide. The river Under runs down the valley 150 feet below the level of the cultivated lands.

Vale of the Baum.—The neighbouring valley of the Baum river, unlike that of the Under, originates about seven miles from the crest of the Ghàts, at a spot where the mountain masses separate into two spurs. Hence it continues level for fourteen miles, gradually widening eastward. The Baum river, like the Under, runs at a level of 150 feet below the cultivated lands; these lands, in fact, being upon one terrace, the river upon a second and lower terrace.

Vale of the Beema.—The next valley on the north is that of the Beema river. The river rises on the elevated table-land above the Ghàts, at 3090 feet, and within the first few miles it tumbles over several terraces. The valley, for eighteen miles, is occasionally as narrow as that of the Mota river.

Vale of the Goreh.—Next on the north occurs the valley of the Goreh river, which, from the source of the river to Munchur, (twenty-nine miles,) is exceedingly narrow and tortuous. Here it expands into the broad horizontal plain of Kowta, ten miles wide.

Vale of the Malsej Ghàt.—In conclusion, as a contrast to the first part of the Goreh valley, I must mention the valley of the Malsej Ghàt, on the south of the Dukhun-base of the fort of Hurreechundurghur. It is several miles wide, and literally as level, even to the brink of the Ghàts, as if smoothed by art. Many of the valleys of the Ghàts, particularly that of the Mool river, from the continued scarped character of the marginal mountains, and the flatness of the bottom for miles in extent, look like fosses to a Titan's fortress.

If all these valleys be valleys of excavation, the present rivers could scarcely produce such, were we to suppose their powers of attrition in operation from the origin of things even to the end of time!

Those of a fissure-like character might have resulted from the upheaving of the beds of trap from below the sea, and the consequent probable fracture of the surface; but the same explanation will not apply to those valleys associated with the preceding, broad, flat, and margined by scarped mountains, which valleys are as wide at their origin at the crest of the Ghàts, and at the sources of the rivers which run through them, as in any part of their length.

Terraces.

As the rise from the Konkun to the Dukhun is by terraces, so the declination of the country eastward from the Ghàts is by terraces; but these occur at much longer intervals, are much lower, particularly in the eastern parts, and escape the eye of the casual observer. In the neighbourhood of Munchur, on the Goreh river, there are five terraces rising above each other from the east to the west, so distinctly marked, that the parallelism of their planes, to each other and to the horizon, gives them the appearance of being artificial. An artificial character also pervades the form of many insulated hills: some of which viewed laterally, appear to have an extensive table-land on the summit,

but seen endways look like truncated cones. Conoidal frustra in the Gawelgurh range have been already noticed. Other insulated hills are triangular in their superficial planes, as the forts of Teekoneh (three-cornered) and Loghur.

Escarpments.

Stupendous escarpments are occasionally met with in the Ghàts. In these instances the numerous strata, instead of being arranged in steps, form a continuous wall. At the Ahopeh pass, at the source of the Goreh river, the wall or scarp is fully 1500 feet high* ; indeed, on the north-west face of the hill fort of Hurreechundurghur, the escarpment can scarcely be less than double that height. On the other hand, the steps are sometimes effaced, and a hill has a rapid slope. This originates in a succession of beds of the softer amygdaloids, without any basaltic interstratification ; their superior angles disintegrate, and a slope results. But most usually three or four beds of amygdaloid are found between two strata of compact basalt ; the former disintegrates, leaving a slope, which is not unfrequently covered with forest trees, forming a picturesque belt : the basaltic scarp remains entire, or it may be partially buried by the debris from the amygdaloids above ; but its great thickness usually preserves it from obliteration, and it rises from the wood below with majestic effect, its black front being finely contrasted with the rich and lively green of its sylvan associate. It is these strata, arranged in slopes and scarps repeated three or four times, and so commonly met with in insulated and other mountains in Dukhun, that constitute the amazing strength of the hill forts of the country, leaving a succession of natural walls encircling a mountain. This feature did not escape the observation of Captain Dangerfield in Malwa, who says, "From the great difference in the resistance made to decomposition by "these trap and amygdaloid beds, their exposed ends acquire a very distinct "degree of inclination and character ; the amygdaloid forming a great slope, "and affording a loose mould covered with vegetation, the trap retaining its "original perpendicularity and dark bareness†."

In the alternation of the strata there does not appear to be any uniformity ; but the general level, thickness, and extent of a stratum are preserved, as in sedimentary rocks, on both sides of a valley ; the basalt and hardest amygdaloids being traceable for miles in the parallel spurs or ranges ; but the imbedded minerals, and even the texture, vary in very short distances.

Columnar Basalt.

A great geological feature of Dukhun is the occurrence of columnar basalt.

* Plate XXVIII. fig. 1.

† Malcolm's Central India, Appendix, p. 322.

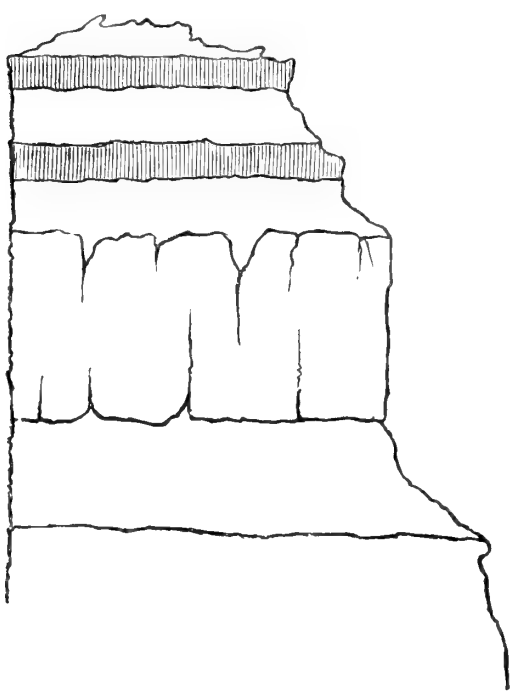
The basalts and hardest amygdaloids run so much into each other that the line of separation is not always readily distinguishable, excepting of course the lines of horizontal stratification. I observed the prismatic disposition more marked and perfect in the basalt strata than in the amygdaloids, and the more or less perfect development of determinate forms was dependent on the compactness and limited constituents of the rocks. Basalts and amygdaloids, however compact, with many imbedded matters, rarely formed columns. Perfect columns were generally small, of four, five, or six sides; but the prismatic structure sometimes manifested itself in basaltic and amygdaloidal columns many feet in diameter. A bare mention of the places where they occur will testify to their extended localities.

On the low table-land of Kurdah, near Serroor, between sixty and seventy miles east from the Ghàts, columnar basalt occupies an area of many square miles. Small columns are seen in most of the slopes of the very narrow sinuous valleys of the flanks of the platform, and frequently the tops or terminal planes of columns are observed on the table-land forming a pavement. The perfect columns in the flanks are generally small, four, five, or six-sided, and rest on a stratum of basalt or amygdaloid. In some spots the columns are articulated, in others not. In a mass of columns in the face of the table-land towards Serroor the columns are of different lengths, but spring from the same level. More articulations having been washed from the outer columns than from the inner by monsoon torrents dashing over them, a pretty flight of steps remains. The columns of this table-land are for the most part erect, but sometimes stand at various angles to the horizon, usually at 45°. In one instance, near the village of Kurdah, they lean from the east and west, towards a central upright mass: these are about fourteen feet in length, and are not articulated. In a mass of columns facing the west, and two miles south of the cavalry lines at Serroor, some are bent and not articulated; they are nevertheless associated with straight columns, which are articulated. At Karkullah, thirty miles north-west of Poona, between Tellegaon and Loghur, a hill has been scarped for the great military road. Very numerous small columns occur in the escarpment, and they lie piled upon each other in a horizontal position; the only instance of the kind within my knowledge in Dukhun. Two or three hundred yards west of the village of Yewtee Purgunnah Kurdeh, in the rocky banks of a rivulet, imperfect columns are seen. On the right bank they are so marked, as to have excited the attention of the natives (an unusual event); and they are daubed with red lead, in the manner of Hindoo deities, and venerated.

At Kothool, twenty-two miles south of Ahmednuggur, there is a thick stratum of close-grained gray homogeneous basalt in the face of the hill on which is seated the temple of Kundobah. Vertical and horizontal fissures are seen in the lateral plane or exposed edge of this stratum, but they are so far from each other as to leave huge blocks between them, giving the appearance of the superstratum of the hill being supported by massive articulated pilasters. Parts of the exposed edge are detached from its mass, leaving rude columns four or five feet in diameter, eight or ten high, and composed of three or four weighty stones disposed to assume geometrical forms. In the water courses near Kurroos Turruf Ranjungaon, columns are observable. The basalt is bluish gray, compact, has a vitreous hue, and sharp fracture. The columns occur very abundantly in the slope of the hills, on either side of a very narrow valley running westward from the village of Ankoolner, Ahmednuggur Collectorate. They are five- or six-sided, articulated, and from a foot to two feet and a half in diameter, and of various lengths; the lateral planes perfect, but in

some instances the sharpness of the angles has been affected by weathering. The texture is close-grained, colour almost black, and they affect the needle.

At Jehoor, near the source of the Seena river, in an insulated hill, an obscure columnar disposition is met with in a rock, in which in other places I had not seen the slightest trace of it. A stratum of red, cellular, amygdaloid fifteen feet thick has subcolumns in its exposed edges eight or ten feet in diameter. In the banks of a water-course running into the Hunga river, half a mile east of Parneir, on the elevated table-land between the cities of Ahmednuggur and Joonur, basaltic columns are very numerous; they are five or six feet high, not articulated, and are not quite perpendicular. This formation is evidently extensive, as the ends of columns, chiefly pentangular, appear in the bed of the water-course for some distance, forming a pavement of geometrical slabs. The ends of columns of different lengths also appear in the southern bank at intervals, forming flights of steps. The basalt of which these columns are composed is very close-grained, almost black, with shining specks of a metallic lustre. The rocky banks of the Kokree river at Jambut, in the plain of Joonur, exhibit a strong inclination to a large columnar structure. In the hill fort of Singhur, at an elevation of 4162 feet, at the western end of the fort, there is a sheet of rock which has the appearance of a pavement of pentangular slabs. The slabs are no doubt the terminal planes of basaltic columns. The same is observed in the hill fort of Hurreechundurghur, about seventy miles north of Singhur; also in the bed of a water-course one mile north-east of Barlonee, near the fortress of Purrunda, 112 miles east-south-east of Singhur; and, lastly, in the bed of the Mool river at Gorgaon, Poona Collectorate. These pavements extend to Malwa, as Captain Dangerfield mentions their occurrence in the beds of the Chumbul and Nerbuddah (Nermada) rivers*. The other localities of basaltic columns, or a marked disposition to this structure, were in a well at Kumlepoor, between the fortress of Purrunda and Barlonee, near the left bank of the Seena river; at Kheir Turruf Rasseen, in the face of a headland, abutting on the Beema river, on which the town stands; in the ascent to the temple of Boleshwur Turruf Sandus, Poona Collectorate; and, finally, in the scarps of a mountain running down into the Konkun, and seen from the Naneh Ghàt, about three miles distant. Here the Giant's Causeway in Ireland is brought to mind; but the scale of the mountain is infinitely more magnificent, being fully 4000 feet high. There is a double row of columns; but from their inaccessible situation, I could only examine them through my telescope, and cannot testify, therefore, to their perfect development; but the accompanying sketch will give a just idea of their appearance to me.



Captain Dangerfield only once speaks of columns. They lie about a mile from the Nerbuddah (Nermada), between Mundleysir and Mhysir, at 696 feet above the sea: they are either

* Malcolm's Central India, Appendix, pp. 329, 330.

vertical or highly inclined. General Hardwick has published a lithographic sketch of them*. I have already stated that Dr. Voysey found columnar basalt in many places in the Gawelghur range.

Schistose Structure.

Following the preceding formation, I may mention, that in some few places a schistose structure was met with; but its extent was limited to a few yards, the lamellæ were vertical, from an inch to three inches in thickness, being perfect tables, with parallel bounding planes. The rock in which this structure occurs, is a simple, indurated, gray clay, which flies into fragments under slight blows from the hammer. At Dytneh near Serroor some very perfect specimens have led the inhabitants to connect mystic influences with so artificial a development of inorganic matter. The spot is daubed with oil and red lead, and venerated.

Basalt en boules.

Another characteristic feature is the general diffusion of those rounded or oval masses of compact basalt, with concentric layers like the coats of an onion, which the French geologists denominate "Basalt en boules", and ourselves, nodular basalt.

These concretions are usually found at the base of hills, buried in the debris from the decomposing strata; but in the Konkun, between Choke and Campolee, (the latter at the foot of the Bore Ghàt,) two villages on the high road between Bombay and Poona, I met with them lying on the surface over a considerable area. They occur in a similar manner on the table-land of the ball-practice hill at Poona. At Koothool (already mentioned), in the slope of the hill, and in the debris at its base, and along the edge of the table-land near Paubul, they are abundant; but the finest specimens are seen near the village of Karkullah, thirty miles north-west of Poona, associated with horizontal basaltic columns. The hill has been cut away, to form the great military road. In making the escarpment the balls were met with, and it being impossible to cut through the nuclei in vertical sections, it was either necessary to leave them projecting or to remove them altogether: in the latter case cavities remained equal to the hemispheres of the nuclei; and the vertical sections display from ten to fifteen concentric layers of friable gray stone, which in some instances I have found to affect the needle. I compared specimens of the nuclei; with a mass brought by me from the Solfatara at Naples, and found them quite similar in aspect, colour, hardness, and great weight. This formation excited the attention of those gentlemen who have visited the northern and eastern parts of the great trap region†; but Dr. Voysey was quite mis-

* Malcolm's Central India, Appendix, p. 323.

† Dr. Voysey says, "The nodular wacken or basalt is one of the most common forms of trap "in the extensive districts composed of the rocks of the family south of the Nermada (Nerbuddah) "river. It occurs perpetually in the extensive and lofty range of mountains, (the Gawalghur) "situated between the Purna and Tapti rivers, and appears to form their principal mass. It is "found equally abundant throughout the whole of Berar, part of the provinces of Hyderabad, Beder "and Sholapoor, and appears to form the basis of the great western range of trap hills which separate "the Konkun from the interior of the Dukhun."—*Physical Class, Asiatic Researches,* pp. 126, 189.

taken in supposing it formed the basis of the Western Ghàts. Captain Coulthard speaks of it in Sagar*. Major Franklin also noticed it in the trap of Sagar, in lat. 23° 51′, and long. 78° 44′, at 1933 feet above the sea, as "frequently globular; the nuclei of the decaying masses, varying in "size from an egg to a large bombshell, and their decomposing concentric lamellæ being generally "very thin, and often very numerous"†.

Dykes.

I now pass to the basaltic dykes, several of which came under my notice in different parts of the country. They are all vertical, and I did not observe that they occasioned any disturbance or dislocation in the strata of basalt and amygdaloid, through which they passed.

Two dykes run obliquely across the valley of Karleh, (35 miles north-west of Poona), and intersect each other: they are about four feet thick and cut amygdaloidal strata. A prismatic disposition is generally observable in the fracture, and from one of them I obtained a square prism, which lay at right angles to the walls of the dyke. The texture is compact. The military road running through this valley and down the Bore Ghàt to Panwell, is frequently crossed by ridges which I presume to be the outcrops of dykes. A dyke is seen on the southern slope of an insulated hill, near the villages of Bosree and Digghee, $7\frac{1}{2}$ miles north of Poona‡. It is about four feet thick, has a transverse prismatic fracture, is compact, and runs from the bottom to the top of the hill; but it is not discoverable in the northern slope. It is visible from the cantonments at Poona. A similar dyke occurs in the hill at Ombreh, twenty miles north-north-west of Poona. But the most remarkable dyke runs vertically, from east to west, through the hill fort of Hurreechundurghur. It is first seen, of a thickness of six or seven feet, in the ascent of the mountain on the south-east from Keereshwur, about 400 feet below the crest of the scarp. The path of ascent into the fort is intersected by it, and its prismatic fracture, at right angles to its planes, offers a few available steps in the ascent. It is traceable for about 300 feet in perpendicular height. On the top of the mountain, within the fort, about a mile to the westward, it is discoverable at intervals, cutting through basaltic and amygdaloidal strata. I could not ascertain whether or not it appears in the western scarp of the mountain, the point to which it directs its course being wholly inaccessible.

The gentlemen whose geological memoirs I have quoted, rarely advert to the subject of trap dykes, and their notices are very brief. Capt. Dangerfield says, "The trap of the southern boundary of Malwa is much intersected by verti-"cal veins of quartz, or narrow seams of a more compact heavy basalt, which "appears to radiate from centres§." Beyond the continuous trap region of the peninsula, Dr. Voysey notices a basaltic vein in sienite, near the Cavary river

* "The base of the hills is invariably broader than the summit; and if the sides of a hill are "smooth and even, *balled* trap, often a concentric lamellar variety will be the principal component "matter, decomposing and decomposed into a predominating workable clay, still showing the "parallel converging layers."—*Physical Class, Asiatic Researches*, p. 78.

† Physical Class, Asiatic Researches, p. 30.

‡ See Plate XXVIII. fig. 1.

§ Malcolm's Central India, Appendix, p. 330.

at Seringapatam, which must have been propelled upwards, as it broke through an oblique seam of hornblende in the sienite, and carried the pieces up above the level of the hornblende vein*. "On the eastern coast," Mr. Calder says, "from Condapilli northward, the granite is often penetrated "and apparently heaved up by injected veins or masses of trap, and dykes of "greenstone †."

Ferruginous Clay.

The next distinctive feature is the occurrence of strata of red ochreous rock, in fact, Mac Culloch's ferruginous clay underlying thick strata of basalt or amygdaloid, precisely as is seen to be the case in the Giant's Causeway in Ireland. It passes through every variety of texture, from pulverulent, friable, and indurated, to compact earthy jasper. The stratum is from an inch in thickness to many feet. The rock makes a red streak on paper, with the exception of the very indurated kinds, and does not affect the needle. It is pulverulent near the basaltic columns at Serroor, friable under sub-columnar red amygdaloid, near the source of the Seena river, indurated under basalt at Kothool. Although hard, it is here so cellular as to have the appearance of sponge, and reduced to powder, looks like brickdust.

In the scarps of the hill fort of Hurreechundurghur and a mountain near Joonur in which are excavated numerous Boodh cave temples, it is found compact and homogeneous, and is, in fact, an earthy jasper. In these localities it lies under from 300 to 600 feet of basalt. In the former locality it is about three feet thick, in the latter one foot. At Nandoor, north-north-west of Ahmednuggur, in the valley of the Godavery river, it is found as a porphyritic stratum many feet in thickness, and is used as a building stone. The imbedded matter consists of very minute crystals of lime. At Wangee, lying nearly in the latitude of Barlonee, but differing 18 miles in longitude, and at Barlonee it occurs as an earth: as both places lie on the same level, I have no doubt the stratum is continuous between them. It occurs abundantly in the Ghâts, frequently discolouring the rivulets, and giving a ferruginous character to the soil over a considerable area. When thin, and under heavy beds of basalt or amygdaloid, the exposed edge of the stratum projects, is rounded, and double the thickness of the stratum itself; as if it had once been in a tenacious fluid state, and squeezed out by the superincumbent basalt. Such is the case at Jehoor, and an illustrative specimen accompanies this paper.

Pulverulent Limestone.

Limestone is met with, in the Dukhun, only in three states: pulverulent, nodular, and crystalline. The first occurs in thin seams on the banks of rivers and water-courses and at the base of hills in debris. The seams are from an

* Physical Class, Asiatic Researches, part i. p. 22.

† Ibid., part i. p. 10.

inch to three feet in thickness, covered by a few feet of black earth. Sometimes in whiteness it resembles pounded chalk, and is then used by children to smear their writing boards.

In this state it occcurs at Jehoor and Islampoor near Ahmednuggur. At Kurkumb and at Salseh, ten miles south of the fortress of Kurmaleh, it is met with under black earth in unusually thick strata, and of a peculiar whiteness. Major Franklin notices "a stratum of earthy limestone, white as chalk, at Sagar, occurring under a stratum of amorphous trap*."

Nodular Limestone.

The nodular limestone, which is the well-known kunkur† of India, (*kunkur* being a native word for nodule,) occurs, like the preceding, disseminated or diffused in the soil, and also on the surface. I have never seen the nodules of a regular crystalline form. They vary in size from a marble to a twelve-pound shot, and many of them are exceedingly irregular in shape, particularly those dug from the banks of rivers. They are sometimes obscurely lenticular. They are so abundant in certain localities that they appear as if showered upon the earth, and disguise its colour. Dr. Buchanan mentions the same in Rajmahl. When upon black soil, they are usually minute and tolerably uniform in size: on other soils their form is variable. In the Ghàts neither pulverulent nor nodular lime is met with. It is unnecessary to particularize the localities of the nodular kind, as it is of common occurrence eastward from the hilly tracts of the Ghàts, and is the only source of lime for mortar, a class of persons making a livelihood by collecting the larger nodules. When carefully burnt, they make an excellent cement. Captain Dangerfield describes "the occurrence (in Malwa) in some parts, particularly near the bottom of the small hills and banks of the rivulets, of a thin bed of loose marl or coarse earthy limestone‡".

Captain Coulthard says, "In Sagar a white patch of this limestone moulder-
"ing by the weather is the source from whence comes the particles of kunkur,
"mixed with the black basaltic earth of the neighbouring valley, in such pro-
"portion as to add increased fertility to it; and if a rivulet meanders through
"that valley (and such is generally the fact), patches made up of aggregated
"particles of the same, will here and there be found; and this it is which the
"native families pick out and work into lime §". Captain Coulthard refers the origin of the nodules to limestone rock underlying basaltic strata, but I

* Physical Class, Asiatic Researches, part i. p. 30.

† The Mahratta word is not spelt with an "a."

‡ Malcolm's Central India, p. 328.

§ "Trap of the Sagar District," Physical Class, Asiatic Researches, p. 60.

cannot trace them to such a source, not having seen strata of compact limestone, properly so called, in the Dukhun. The only specimen of compact limestone met with by me was in the bed of the Beema river near Pundurpoor. It was an insulated, amorphous, gray mass, four or five feet in diameter. I looked upon it as an aggregation of the pulverulent particles of the lime disseminated in the neighbouring banks. A specimen of it accompanies this paper.

Crystalline Limestone.

Lime in a crystalline state occurs only as an imbedded mineral in the amygdaloidal strata, in quartz geodes, and in the nucleus or compact part of masses of mesotype or stilbite. It is rare compared with the preceding varieties.

Loose Stones.

Another feature of Dukhun is the occurrence of immense quantities of loose basalt stones, as if showered upon the land; also masses of rock heaped and piled into mounds as if by the labour of man. Their partial distribution is not less remarkable than their abundance. For the most part, the stones have a disposition to a geometrical form, and it is by no means rare to meet with prisms of three or four sides and cubes almost perfect: stones with one or two perfect planes are very common. Their texture is close-grained and the colour verging to black.

At Dehwuree, Hungawaree, Behloondee, Kothool, and Dytneh in the Ahmednuggur Collectorate, they are very abundant. At the last place they cover fields several acres in extent, so thickly that the black fertile soil on which they rest is not discoverable: they vary from an ounce to several pounds in weight. Amongst these I picked up a perfect square prism. In neighbouring fields, most unaccountably, there is not a stone to be seen: patches of sheet rock occur in their vicinity. Other localities are the top of the Neem Durra Ghàt near Ahmednuggur; the junction of the Beema and Seena rivers below Mundroop; right bank of the Seena at Kurmaleh; between Kurjut and Meerujgaon; and generally it may be stated that the precipitous slopes of the low table-lands of the Desh (open or flat country) are very strong and rocky. For ten miles between Jeetee and Soagaon, Ahmednuggur Collectorate, the fields, and even the road, are so thickly strewn with large basalt stones as to render cultivation difficult and travelling penible.

Rocky Heaps.

The singular heaps of rocks and stones above noticed occur at Kanoor, Patus, Kheir, between Kurjut and Meerujgaon, and at other places in the Desh, but not in the Mawals, or hilly tracts of the Ghàts. The heaps are from twenty to seventy feet in diameter, and the same in height: when composed of rocky masses without small stones, blocks of three or four feet in dia-

meter and with a disposition to determinate forms, are piled upon each other, constituting rude pillars. In certain parts of the country from fifty to sixty of these heaps are seen within the area of a couple of square miles, and it excites surprise that the intermediate ground is destitute of stones.

Sheets of Rock.

Mention must not be omitted of the constant recurrence of sheets of rock of considerable extent at the surface, and totally destitute of soil: this is particularly the case in the Mawals, or hilly tracts along the Ghàts. They abound with narrow vertical veins of quartz and chalcedony. When of sufficient thickness, the vein splits in the centre parallel to the surface of its walls, the interior being drusy with quartz crystals: the walls consist of layers of chalcedony, cachalong, hornstone, and semi-opal. These veins supply the majority of the siliceous minerals so abundantly strewed over Dukhun.

The localities where the sheets of rocks particularly struck me were Lakungaon, on the plain of Joonur, and generally in the valley of the Goreh river; at Kothool, Pergunneh Kurdeh; at Kheir and Raseen; in the hill fort of Hurreechundurghur; most markedly between Kooldurrun and Pairgaon on the Beema river. At Aklapoor, on the Mool river, they were very extensive; and at Angur, Mohol, Kurjut, and Patkool. Generally in the eastern and south-eastern parts of my tract, much decomposing amygdaloid is found at the surface of the low table-lands or terraces, which, in favourable monsoons, is equal to the support of Jowaree*; but a small deficiency in the rains occasions the destruction of the crop.

Structure and Mineral Composition of the Trap Rocks.

The structure and mineral composition of the trap rocks in Dukhun vary exceedingly in short distances, even in the same stratum; nevertheless, the predominant character does not disappear, although the basalt in a continuous bed may pass several times from close-grained, compact, and almost black, to gray, amygdaloidal, and externally decomposing. The same observation applies to the amygdaloids. A variety of compact basalt, of an intense green colour, is susceptible of a brilliant polish, and rivals the celebrated Egyptian kind. It is of great weight and remarkable hardness: the natives use it to work into idols for their temples, pedestals to the wooden columns in their mansions, and slabs for inscriptions. The bulls of the size of life, always placed before the temples of Mahadeo, are cut out of this variety at Raseen, Wurwund, and the renowned Boleshwur. Some of the pedestals in the gateway of the Mankeswur palace at Teimboornee look like

* *Andropogon Sorghum.*

mirrors. In the temple at Pooluj south of Punderpoor, there is a slab six or seven feet long and $2\frac{1}{2}$ broad, covered with an inscription in the Kanree language; and in Punderpoor the streets are paved apparently with the same basalt. At Jehoor and near Ahmednuggur is found a compact kind like the last, but not so heavy. It has a crystalline character and sharp fracture, and has angular siliceous pebbles imbedded: an occasional pebble is loose in its cell. In the Happy Valley near Ahmednuggur the basalt is compact and smooth, with reddish flat transparent crystals imbedded. It opposes a feeble resistance to the hammer, and flies into fragments, some of which have right angles. The basalt, even of the true columns, is not of a uniform texture in different localities: at times it is blackish or gray, and very small, granular or compact; at others, earthy and ferruginous, particularly externally. The basis of the amygdaloids is clay, with more or less hornblende disseminated: they embrace the cellular, porphyritic, hard, friable, and decomposing. I endeavoured to class them agreeably to the prevalence of quartz, chalcedony, lime, mesotype, or stilbite, as imbedded minerals, but found the method of very limited application. Sometimes one mineral only is imbedded, occasionally two, and often the whole.

In Hurreechundurghur quartz amygdaloid prevails: at Aklapoor on the Mool river it is characterized by mesotype, that mineral being imbedded in large masses, and the radii (six or seven inches) are the longest I have seen. At Nandoor it is porphyritic with minute crystalline specks of lime: near Ahmednuggur is seen a cellular, indeed spongiform kind, which is hard, and the cells are empty. A small cellular and pisiform variety is found in the wonderful cave temples of Ellora, and some of the sculptured figures appear as if marked by the smallpox. This observation is partially applicable to the Boodh and Hindoo cave temples of Elephanta, Salsette, Karleh, Joonur, the Naneh Ghàt, and the Adjunteh Ghàt; all of which are excavated in basaltic or amygdaloidal strata. The stilbite or Heulandite amygdaloid is of very common occurrence; but the most prevalent kind is that in which all the minerals noticed above are associated. The stone usually selected for building is of various shades of gray or bluish gray; has hornblende disseminated in very small crystals; works much easier than some of the compacter basalts, but takes a good polish. The entire temples of Koorul and Boleshwur, with their innumerable alto-relievo figures and laboured ornaments, are built of this variety of trap, which is, in fact, a greenstone, although less crystalline than the European rock. There is a variety selected carelessly, also used in building, which has the structure and nearly the external characters of the last, but which, in weathering, exfoliates, and the

buildings fall to ruin; such is the case with the great temple in Hurreechundurghur.

I must not omit mention of two remarkable rocks which, as far as my reading extends, have not been noticed by authors on European geology. The first is an amygdaloid in which compact stilbite is imbedded in a vermicular form. One of its localities is the insulated hill on which stands the temple of Parwuttee in the city of Poona*; and it is met with in many other places. Captain Dangerfield observed the same peculiar stratum near Sagar. He says, "There occurs an amygdaloidal or porphyritic rock consisting of a compact basis of wacké, in which are imbedded in great abundance small globular or uniform masses, but more usually long *curved* cylindrical or vermiform crystals of zeolite †."

The other rock occurs as a thick stratum of amygdaloid at the elevation of 4000 feet, in the hill forts of Hurreechundurghur and Poorundhur; and in the bed of the Goreh river at 1800 feet, near Serroor. The matrix resembles that of the other amygdaloids, but the mineral imbedded is a glassy felspar in tables resembling Cleavelandite, crossing each other at various angles, and so abundant as to occupy a moiety of the mass. I have only remarked it in the above localities, and it does not appear to have come under the notice of the gentlemen I have so often quoted in other parts of the peninsula.

Minerals.

Minerals are not uniformly dispersed in Dukhun. In one part quartz predominates, in another chalcedony; and these are more or less associated with jaspers, agates, hornstones, heliotrope, and semi-opal or cachalong. In other places particular members of the zeolite family prevail, nearly to the exclusion of the siliceous class; and elsewhere there is a diminution of minerals amounting almost to privation. Amethyst quartz is rare in Dukhun; when met with it constitutes the crystal, lining the interior of geodes of agate. I have not seen it in veins. Pseudomorphous quartz is common; the most frequent impression is that of rhomb spar. Lime occurs only in three crystalline forms: rhomb, dog-tooth, and the dodecahedron. The first is found on the surface, and imbedded in masses of quartz and compact mesotype; the two latter forms are associated with ichthyophthalmite in cavities in the amygdaloid strata ‡.

* See Plate XXVIII. fig. 2., near to the city of Poona.

† Central India, p. 328.

‡ That comparatively rare European mineral, ichthyophthalmite, is most abundant and of great beauty in the neighbourhood of Poona.

The following are a few of the mineral localities:

At Kothool, south of Ahmednuggur, the numerous quartz and chalcedony veins cover the country with agates, colourless quartz-crystals, and chalcedony; some of the specimens are fully a foot thick, including both walls of the vein. Here are met with some few crystals of calcareous spar inclosed in quartz. At Ahmednuggur, to the above siliceous minerals, some members of the zeolite family are to be added, principally stilbite. At Nandoor, on the plain of the Godavery river, the zeolites disappear, and the siliceous minerals are limited in number. On the contrary, at Jamgaon, eighteen miles west of Ahmednuggur, on the upper terrace or plateau, in addition to all the minerals enumerated, bits of yellow and red jasper and heliotrope occur. Ascending the Mool river from Nandoor, at Aklapoor, great masses of mesotype, with radii several inches long, are found imbedded in friable amygdaloid. North of Aklapoor, at Gorgaon, a new mineral occurs in a mass two feet in diameter. Its depth I do not know, as it lay partly buried in the amygdaloid bed of the river: its colour green, and breaking into rhombs. Gorgaon is the only locality known to me of this mineral. Its measurements are those of calcareous spar, but the specific gravity is less. It is stated to be coloured by green earth. It is interesting from being unknown in the cabinets in England.

A few miles further up the Mool river, at the village of Chas, in the shoulder of a hill formed of numerous thin horizontal beds of decomposing amygdaloid, many specimens of cloudy calcareous spar, imbedded in stilbite, are found, and the siliceous minerals are rare. Ascending to the source of the river the same scarcity prevails. Three miles south-south-west of Chas, at Brahmunwareh, great masses of stilbite, of the radiating foliate kind, are imbedded in hard amygdaloid. In the hill fort of Hurreechundurghur, although siliceous minerals are not abundant, crystallized quartz of various colours is seen, a feature not characterizing the Desh or open country. South of Ahmednuggur, as far as Soagaon on the Beema river, and Meerujgaon on the Seena river, the Ahmednuggur minerals prevail; hence descending the Beema to its junction with the Seena, a gradual diminution takes place, and at the junction they almost disappear; returning north, at Ashtee, between Kurkumb and Mohol, a few are met with. At Oondurgaon, and up both banks of the Seena river to Purrunda, numerous and very fine specimens of milk opal, with a flame-coloured tinge in transmitted light, are found on the surface; and this is the only locality where I met with opal as a distinct mineral; and here the members of the zeolite family are very rare. At Tudwull, between Oondurgaon and Barlonee occur the only specimens of black calcareous spar seen by me in Dukhun; it is associated with transparent calcareous spar. In excavating wells in the cantonments at Poona, splendid specimens of ichthyophthalmite were brought to light; and generally in the bed of the river Mota-Mola and the neighbourhood, fine specimens of heliotrope and coloured quartz occur. The other minerals are *nadelstein*, *analcime*, *chabasite*, and *laumonite*. Captain Dangerfield's details prove that the minerals of Malwa are identical with those of Dukhun.

Natural Salts.

Only two kinds of natural salt came under my notice, namely, muriate and carbonate of soda.

With respect to the former, many of the wells at Ahmednuggur are brackish; and there is a rivulet running into the Seena river about two miles north-west of the city, which has its source a few miles distant, called the Salt Brook. It passes over a saliferous soil; and in its dry bed, or

on insulated stones standing in its stream, are incrustations of common salt intimately mixed with carbonate of lime. No use is made of this salt. The saline impregnation of the soil extends to some distance west and north-west of Ahmednuggur, as I found a handsome well at Kurjooneh, eight miles distant, filled with water so brackish as not to be available for domestic use. At Wurgaon, between Kurjut and Pairgaon, a peculiar hoary appearance of a patch of ground in the midst of withered grass, led me to examine it. The whiteness was occasioned by lime in minute particles, mixed with a little muriate of soda.

The third locality of common salt was in the bed of a rivulet at Koond Mawlee, near the falls on the Kookree river, between Serroor and Kowta. A little common salt, with a trace of carbonate of soda, appeared, incrusting the rocky bed for a few feet near the water line. I did not observe common salt elsewhere. My attention was first directed to carbonate of soda at Serroor, by observing washermen digging for earth in the banks of a rivulet; learning that they used it to wash their clothes, I obtained a quantity; lixiviated the earth, boiled down the lixivium, and on cooling obtained a large crop of crystals, which the usual tests indicated to be carbonate of soda. I only met with one other bed, although I have no doubt they are numerous. At Kalbar Lonee, twelve miles east of Poona and two miles south of the Mota-Mola river, within an area of 200 yards, a constant moisture and partial absence of vegetation is observed. An efflorescent matter appears on the surface every morning, which is carefully swept up and sold to washermen: it is carbonate of soda. The occurrence of salts in the trap formation did not escape Captain Dangerfield's notice. He states that "the banks of the Nerbuddeh (Nermada) near Mundleysir, consist of an upper thin bed of vegetable mould; a central bed, chiefly of indurated marle, strongly impregnated with muriate of soda; and a lower bed, of a reddish hue, with much carbonate of soda. In the dry season these salts form a thick efflorescence on the surface of the bank*." Saltpetre is manufactured in Dukhun, not from nitrated soils, but from the scrapings of old walls. I have also seen specimens of muriate of ammonia obtained by the brick and tile makers in burning dung, stable and other refuse matters in their kilns.

Ores.

No other ore than that of iron is found in Dukhun. It is only worked, to my knowledge, at Mahabuleshwur, at the source of the Krishna river. It occurs as a nodular hematite, associated, I understand (for I have not been at the spot myself), with laterite. This ore produces the celebrated Wootz steel.

Organic Remains.

I did not meet with organic remains of any kind whatever. Captain Coulthard† in Sagar, Major Franklin in Bundelkand, and Captain Dangerfield in Malwa, were equally unsuccessful. Dr. Voysey, indeed, mentions a bed of freshwater shells in a stratum of indurated clay near the Tapty river in the Gawelghur hills; also at Medconta, 2000 feet above the sea, on trap; but these may have been recent, as he does not say to the contrary‡. Mr. Calder, in his general observations on the Geology of India§, says, "But hitherto the

* Malcolm's Central India, p. 324.

† Physical Class, Asiatic Researches, p. 81.

‡ Physical Class, Asiatic Researches, p. 194.

§ Ibid., p. 16.

most striking phænomenon in Indian geology is the almost total absence of organic remains in the stratified rocks and in the diluvial soil." As this must have been written with a knowledge of Dr. Voysey's paper, it being in the same volume with his own, it is probable he considers the shells recent.

Thermal Springs.

Thermal springs do not exist in Dukhun within my limits; but there are three distant localities in the Konkun below the Ghâts, where hot water gushes up from numerous crevices in trap rocks over an extensive surface.

The first is at Vizrabhaee, forty-eight miles north of Bombay, where the principal springs are in the bed of a river, and in the monsoon are consequently lost in the swollen stream; but in traversing the jungle in the vicinity I have met with detached pools of hot water, which are unaffected by the rains; their temperature is very high. The second locality is that mentioned by the late Dr. White, of the Bombay army. The hot wells are called Devakl Unei, and are fifty miles south-east from Surat*, at the foot of some hills; the temperature in the different springs ranges from 111° to 120° Fahr. They are spoken of as being in the vicinity of Anaval and Veval, but as these places, agreeably to the map of India, are only thirty miles from Surat, there is evidently some mistake with regard to the distance. The third locality is at Mahr, on the Bancoot or Fort Victoria river, about seventy-five miles south of Bombay. I know of these springs only from report. The whole of the above springs, extending through 3° of latitude, lie nearly in the same parallel of longitude (73°), and are within twenty-five miles of the sea.

In a manuscript report to the Government of Bombay, on the province of Khandeish, Colonel Briggs has the following passage testifying to the occurrence of thermal springs above the Ghâts:

"Among the natural curiosities of Khandeish are the hot springs of the Satpoora hills, particularly those of Soonup Deo and Oonup Deo, the former in the district of Arrawud, and the latter in the deserted Pergunneh of Amba. The former is so hot that the hand cannot be borne in it; the latter is less ardent, and is used as a hot bath; they are both said to possess medicinal qualities, and are considered useful in the cure of cutaneous disorders,—amongst others leprosy."

Dr. Buchanan speaks of hot springs at Rishikunda and Bhimband in the trap mountains of Rajmahl†; and the Rev. Mr. Everest mentions a thermal spring associated with a trap bed at Katcamsan, between the 23rd and 24th parallels of latitude, and longitude 86° and 87°‡. Dr. Adam mentions that of Sitakhund near Monghyr on the Ganges§. Dr. Davy speaks of one at Cannina, Ceylon‖; and I am informed they are to be met with in Canara. Mr. Crow, formerly commercial agent of the Bombay Government in Sinde, in his manuscript reports, mentions a thermal spring near Corachee on the Indus, of which the water is almost boiling hot. In Major Cruickshank's manuscript revenue map of part of Goojrat a hot spring is placed at Tooee, near Ruttenpoor on the Mhye river, in latitude north 22° 49′, and longitude east 73° 30′; and there is another at Lawsoondra, eighteen miles west-north-west of Tooee. These instances, which I am satisfied could be multiplied by diligent inquiry, afford ample proof of the wide occurrence in the peninsula of India of those singular phænomena, the satisfactory explanation of the causes of which is still a desideratum in geology.

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* Transactions of the Royal Asiatic Society, 1833.

† Gleanings of Science, vol. i. p. 36.

‡ Gleanings of Science, May 1831, p. 135.

§ Geol. Trans., 1st Series, vol. v. p. 349.

‖ Geol. Trans., 1st Series, vol. v. p. 313.

Craters.

Volcanic products were not seen by me, nor any conformation of the hills that might be deemed an extinct crater; although the porcelain and ferruginous clays, and the exterior coat of the various quartz and jasper minerals indicate their having been exposed to igneous action. Captain Dangerfield did not meet with volcanic matters or craters in Malwa or the Vindhya range, but states a tradition exists of the celebrated city of Oogein, and eighty other places having been destroyed at a remote period by a shower of earth; and the people say that in the Vindhya range and Rajpeeply hills there are hollows near their summits "sometimes filled with water, which may be craters*." As the old city of Oogein stood upon a river constantly overflowing its banks, it was probably buried in alluvium. Mr. W. Hunter attributed its destruction to one of three causes,—earthquake, overflowing of the Seeprah, or drift earth by high winds; and, although the least probable of the three, inclines to drift earth. He states there are not any traces of volcanic agency in the buried city, nor in the neighbourhood †. The remains of the city of Mhysir, on the banks of the Nerbuddeh (Nermada), are found in alluvium. We may safely say, therefore, there are not any indications of volcanic action of a comparatively recent date.

Extent of Trap Region, &c.

I will now offer a few observations on the amazing extent of the trap, laterite, nodular limestone, granite, and gneiss formations in the Peninsula, limiting their application to 25° of north latitude. My personal knowledge of the country extends from the sea on the western side, to Arungabad, in 75° 33′, and Sholapoor, 75° 53′ east longitude; north, nearly to Kandeish, and south, to Beejapoor and the Kristna river. Captain Dangerfield takes up the country on the north, nearly where my knowledge of it terminates, and says, "It (Malwa, including the Vindhya range) appears to constitute the northern termination of a very extensive secondary trap formation, which extends from the extremity of the Dukhun, and probably even Mysore, forming all the country above the Ghàts, and part of the plains below, on the western side of the Peninsula, including the islands of Bombay, Salsette, Elephanta, &c.‡" He carries the continuous trap north to Neemutch, in latitude 24° 27′, at 1476 feet above the sea. Its western limit is at Dohud, longitude 74°. Major Franklin and Captain Coulthard take it up in the eastern limits of Malwa, and trace it through Sagar; and it continues to an unknown extent towards Sohagpoor and the source of the Nerbuddeh river, on the table-land of Amarakantah, in longitude 82° east. Dr. Voysey describes its eastern limits at Nagpoor, latitude 21° 10′ N., and longitude 79° 14′ E. at 1000 feet above the sea. Mr. Calder states it passes from Nagpoor southward by the confines of Hyderabad, as low as the 15th degree of latitude, and taking a north-west direction terminates on the sea-coast at Bancoot or Fort Victoria, in latitude 18°. But specimens of rock shown to me from the Kolapoor country above the Ghàts, between

* Malcolm's Central India, Appendix, p. 325.

† Asiatic Researches, vol. vi. p. 39.

‡ Malcolm's Central India, Appendix, p. 320.

the parallels of latitude 16° and 17° N., bear testimony to the trap extending nearly a degree and a half further south along the Ghàts than Mr. Calder supposed. Indeed its southern limit in the Konkun, Mr. Fraser states to be at Malwan, fifty miles north of Goa*. From the above evidence we have proofs of a continuous trap formation covering an area of from 200,000 to 250,000 square miles, a phænomenon unexampled in any other country whose geological structure has been examined. It appears to me, however, that the above are not the absolute limits of the trap. Dr. Buchanan† and Mr. Jones‡ describe the Rajmahl hills in latitude 25° and longitude 88° to 89° E. as trap; the latter says the basalt is of amazing thickness. The Rev. Mr. Everest§, in a journey from Calcutta to Ghazipoor, passed four distinct broad beds of trap between the parallels of north latitude 23° and 24°, and longitude 84° and 87°. He states these beds to have an inclination to a common axis, and he thinks it probable they are connected beneath the granite and gneiss. Mr. Royle travelling the same route, observed the same beds. Mr. Everest's diagram shows their longitudinal axis on a line between the Rajmahl hills and the sources of the Nerbuddeh and Soan rivers; and as the trap of the Vindhya range and Sagar extends towards these sources, it is very probable the ramifications are connected with the beds (seen by Mr. Everest) and the Rajmahl hills, forming a belt across India from the 73° to the 89° of longitude, extending, in fact, from near the mouth of the Nerbuddeh river to the Ganges at Rajmahl. The southern limit of trap is much lower than is assigned to it by Mr. Calder, as Dr. Voysey describes a basaltic dyke at Seringapatam, in latitude 12° 26′; and Mr. Calder himself mentions partial deposits of overlying rocks as far south as Cotallum, at the extremity of the great western range, between the parallels of latitude 8° and 9°. Mr. Babington, passing through Mysore, describes all the black rocks he met with as hornblende passing into basalt. He evidently adverts also to nodular basalt‖.

Age of Trap.

With respect to the age of the great trap formation of India, it would appear from Major Franklin's Memoir on Bundelkund, that its northern extremities rest on sandstone, which he considers identical with the new red sandstone of England; the trap would therefore be posterior to the carboniferous series and belong to the supermedial order. But the Rev. Mr. Everest¶ adduces valid reasons for questioning the correctness of Major Franklin's opinion; and it may be inferred, that he is doubtful with respect to the exact

* Geol. Trans., 2nd Series, part i. p. 153.
† Gleanings of Science, vol. iii. Jan., 1831, p. 1.
‡ Phys. Class, As. Researches, p. 165.
§ Gleanings of Science, vol. iii. p. 135.
‖ Geol. Trans., 1st Series, vol. v. p. 325.
¶ Gleanings of Science, vol. iii. p. 211.

equivalent in Europe of the Indian sandstone, as it is much associated with the primitive rocks *. In fact, where are the oolitic rocks above, and the magnesian below the red sand, where the rock salt and gypsum, and where, above all, the characteristic organic remains of the lias and magnesian limestone? It would be idle, therefore, to speculate on the era of a formation without a standard of comparison to direct the judgement. The question of the manner of the formation of the horizontal beds of trap with their vertical edges is very interesting. It will be said they were ejected under the pressure of an incumbent ocean. If such had been the case, where are the marine remains, and would not there have been sedimentary deposits upon them? Moveover, if viewed as coulées from craters, would not the beds have thinned out, instead of preserving the parallelism of their superior and inferior planes and their vertical edges?

Laterite.

Laterite is a ferruginous clay mottled red and yellowish. When first dug from its bed, it is soft and is easily fashioned into the form of bricks or large square masses for building; and if my recollection serves me right, it constitutes the material of the walls of the fort at Tellicherry and the jail at Calicut. It rapidly indurates on exposure to the atmosphere. It is destitute of fossils, as far as is yet known.

That curious and very extensive rock, aptly denominated laterite, (I learn from the information of a friend,) occurs at the source of the Kristna river in latitude 17° 59′, at an elevation of 4500 feet above the sea. It covers the low land between the sea and the great western range from the southern Konkun to Cape Comorin, and, agreeably to Dr. Davy, passes into Ceylon. I casually observed it at Tellicherry and Calicut, respectively 744 and 756 miles south of Bombay; and at Calicut granite rises through it. On the low land at the base of the great *eastern* range, Mr. Calder says it reappears between the 11° and 12° parallels of latitude, and recurs in increasing patches passing northwards, covering granite. The Rev. Mr. Everest speaks of laterite forming a fringe to great part of the bay of Bengal and covering the edge of the granite of either peninsula †.

Nodular Limestone.

In addition to the evidence already adduced of the extensive occurrence of nodular limestone, Dr. Buchanan mentions having met with it in Rajmahl trap hills, in Bengal, and in Mysore. A writer in the 'Gleanings of Science' ‡ states that it occurred in repeated borings for water in Calcutta, at from 50 to 112 feet below the surface. Another writer § says, it is "very extensively distri-" buted throughout Hindoostan," and further asserts that it is a "most distin-" guished feature of Indian geology." The Rev. Mr. Everest and Mr. Royle remarked it in their journey before adverted to. The few organic remains

* Gleanings of Science, vol. iii. p. 213.

† Ibid., vol. iii. p. 135.

‡ Ibid., vol. i. p. 169.

§ Ibid., vol. i. p. 365.

hitherto found imbedded, belong to living species. The following is the analysis of "Kankar"* (nodular limestone) by Mr. Prinsep†.

Water of absorption	1·4
Carbonate of lime	72·0
Carbonate of magnesia	0·4
Silex	15·2
Alumine and oxide of iron	11·0
	100·0

Kunkur, or nodular limestone, has been likened to the cornbrash of the English strata; but its geological position (principally superficial), and the absence of characteristic fossils, present insuperable objections to their identity.

Granite.

The late Dr. Voysey states, that he "had reason to believe, partly from personal observation and partly from specimens obtained from other sources, "that the basis of the whole peninsula of India is granite; he had traced it "along the coast of Coromandel, lying under iron clay (laterite); also in the "bed of the Godavery river, from Rajamahendri to Nandair; and he had "specimens from the base of the Sitabaldi hills of Nagpoor, from Travankur, "Tinnevelli, Salem, and Bellari." Mr. Stirling in his memoir on Cuttaek says, "The granite where my specimens were principally collected appears to burst "through an immense bed of laterite (iron clay) rising abruptly at a considerable angle‡." Major Franklin adds to the above quotation, "the plains of "Bundelkhund attest that granite is there the basis rock." Ceylon is exclusively granite and gneiss; finally, I observed granite rising through laterite at Calicut on the Malabar coast. With these facts before us, we can scarcely question the truth of Dr. Voysey's opinion; an opinion involving the belief, with reference also to the extent of trap, that the whole peninsula of India and Ceylon, covering an area roughly calculated of 700,000 square miles, is of igneous origin.

Sedimentary Rocks.

I am not aware of the existence of any sedimentary rocks in Western India, south of Baroach, excepting such as have probably originated in the consolidation of comparatively recent alluvium.

Recapitulation.

I close this paper with a recapitulation of the characteristic geological features of the peninsula; namely,—the amazing extent of the trap region, and the horizontal position of its stratified beds the granitic basis of the whole

* Properly *Kunkur.*

† Gleanings of Science, vol. i. p. 278.

‡ Phys. Class, Asiatic Researches, p. 37.

country ; trap veins in granite ; the absence, as far as is known, of that uniform series of rocks which constitutes the formations of Europe ; the extended and peculiar nodular limestone and laterite formations; the occurrence of pulverulent limestone in seams ; and finally, the non-discovery hitherto of the fossil remains of extinct animals within the limits of the Peninsula.

London,
January 21st, 1833.

A few words are necessary in explanation of the sections which accompany this paper. They represent two principal spurs from the Ghàts, and converge to the same point at the junction of the Goreh and Beema rivers. In strictness they are not sections ;—ramifications of the spurs, and hills at short distances north and south of the central vertical plane being inserted : they partake, therefore, of a slightly perspective character, but this does not affect the general correctness of their geological features. Fig. 1. comprises the range of hills between the Under and Beema rivers, and has a length of about seventy-five miles. Fig. 2. shows the mountains between the Bore Ghàt and the source of the Mota river, and extends nearly eighty miles. The length and elevation are expressed by different scales, and from this cause the outlines of the mountains are not rigidly correct. A bare outline is traced from the Ghàts westward to the sea, for the purpose of showing the curious forms of the weathered basaltic caps and ridges of the mountains in the Konkun.

The elevations were determined either barometrically, or thermometrically. Those marked "B." are barometrical, and result from simultaneous observations with previously-compared barometers ; all the necessary corrections having been applied, for temperature, moisture, and latitude. Those marked "W." were obtained by ascertaining the boiling-point of water at different elevations with delicate thermometers : they are not to be relied upon within 100 feet, although in some instances, when tested by barometrical measurements, they corresponded within a few feet.

Of the Panoramic Sketches, Plate XXVII. No. 1. is a distant view of the mountains, on which are situated the celebrated hill forts of Jewdun, Hurreechundurghur, Koonjurghur, and Sewneir, in which Sewajee, the founder of the Mahratta empire, was born. It is taken from the hill N. of the town of Goreh.

No. 2. is a view of the hills, to the North and East, as seen from Lakungaon in the flat broad valley of Jooneir (Sewneir).

No. 2*. is a continuation of the view No. 2., from the N. round to the West.

No. 3., a sketch of the hills, to the North and East, as seen from the summit of the armoury, in the fort of Ahmednuggur.

No. 4. is a sketch of the northern flank of the plateau, or which the city of Ahmednuggur stands ; as seen from Wamooree, in the plain of the Godavery river.

VIII.—*On the Geology of the Environs of Bonn.*

By LEONARD HORNER, Esq., F.R.SS. L. & E., F.G.S.

[Read March 13, 1833.*]

THE district about to be described lies on the Rhine, from the mouth of the Sieg, below Bonn, to the town of Linz, a distance of about eighteen English miles, and extends nearly five miles inland, on both sides of the river.

A short way above Bonn the Rhine leaves the mountainous land, through which it has flowed with little interruption from its source, and enters a vast plain that extends to the North Sea, the nearest shore of which is about a hundred and thirty miles distant.

The Siebengebirge, or Seven Mountains, are the grand feature in the district, and constitute a group of hills, of very graceful forms, on the right bank of the river. Looking down from one of their higher summits, one sees a numerous assemblage of conical hills and connecting ridges; but when viewed from a distance, and in certain positions, seven peaks rise conspicuously above the rest, and hence the group has received its name. Of these, the most remarkable, as well from its individual form as from its fame in legendary story, is the Drachenfels, with a ruined castle on its summit. But the Oehlberg is the highest point, being 1369 English feet above the level of the sea, or 1209 above the Rhine, the surface of which at Königswinter, a small town at the foot of the Drachenfels, is, at its mean height, 160 feet above the sea†. (*A table of the principal heights will be found in the Appendix*‡.)

The Siebengebirge and adjacent country have been described with more or less detail by several eminent geologists of Germany. The earliest memoir on the volcanos of this district is probably that of "Bartholomæus Hempelmann und Joh. Wilh. Muenster, *Ueberbleibsel erloschener Vulkane in einigen Gegenden des Niederrheins.*" Bonn, 1785. There is a very copious

* Between the reading and the printing of this paper, an interval of three years has elapsed, and during that time some new facts have come to my knowledge, both from my own observations, and from those of other geologists, which will be found in an Appendix, p. 472.—*March*, 1836.

† By the barometrical measurements of Professor Benzenberg of Dusseldorf, in 1824.

‡ Appendix I. p. 472.

work by Nose*, which was published in 1789, and, considering the time when it was written, it possesses great merit, and evinces minuteness of observation. Professor Nöggerath† of Bonn has described some of the more remarkable features of the district, and Messrs. Von Oeynhausen and Von Dechen‡ have given, in a periodical Journal, a general view of what Nose, Nöggerath, Steininger§, and others had written, adding many original observations‖. But to the geologists of England this remarkable district is little known; it is, however, particularly deserving of their attention, for, diversified as is the mineral structure of the British isles, nothing analogous to it occurs in them; and it affords this further attraction, that the Siebengebirge and the neighbouring country of the Eifel are the nearest points to England where volcanic phænomena, at all approaching in character to those of modern times, can be seen. Those who are desirous of studying, on the spot, the effects of volcanic action, by availing themselves of the facilities of steam navigation, may, with great ease, in six days from leaving London, reach the Mosenberg in the Upper Eifel, and there stand by the side of a stream of lava, and, although the fires have been long extinguished, on the edge of a crater covered with cinders. Nor is it to be forgotten, that these numerous objects of geological interest present themselves in a country renowned for the charms of its natural scenery and historical associations.

I have deposited in the museum of the Society a suite of 277 specimens in illustration of this paper, with a descriptive catalogue. The accompanying Map has been coloured in part from my own observations; but as far as the Siebengebirge are concerned, it is, with a few alterations which I have seen occasion to introduce, a copy of one communicated to me by Professor Nöggerath, and which he kindly permitted me to make use of. In a country so covered with a luxuriant vegetation as this is, one cannot say that the boundary lines of the different formations are exact¶, or that all the phænomena which bear upon the geological history of the country have been discovered; future observers will probably see reason to make alterations in these boundaries, and I have no doubt that much remains to reward further researches.

From my learned friends Professors Goldfuss and Nöggerath I derived

* *Orographische Briefe über das Siebengebirge*, &c., 2 vols. 4to.

† *Das Gebirge in Rheinland-Westphalen*, 4 vols., 1822—1826.

‡ *Hertha*, 12th vol., 1828.

§ *Die erloschenen Vulkane in der Eifel, und am Niederrheine*, 1 vol. 8vo, 1820; and *Neue Beiträge zur Geschichte der Rheinischen Vulkane*, 1821.

‖ Professor Nöggerath is now engaged in preparing a full account of the Siebengebirge.

¶ See Appendix II. p. 472.

much assistance in the course of my inquiry, not only in conversation, but also by the liberality with which they laid open to me the valuable collections in the museum of the University under their charge. I am further much indebted to the kindness of the Count von Beust, President of the Council of Mines in the Prussian Rhenish Provinces, who made the extensive geological library and the documents belonging to that establishment freely accessible to me.

General Structure.

The lowest and the prevailing sedimentary deposit of the district is grauwacke, both in the form of sandstone and of slate, a continuation of the same formation which covers so great an extent of country in the Lower Rhine and in the Eifel; but here no limestone beds are associated with it. None of the later secondary strata occur, and the grauwacke is covered unconformably by a deposit of the tertiary period, consisting of a series of beds of sand, sandstones, clays, and lignites, which collectively constitute a brown-coal formation. This is covered by an extensive bed of gravel, and above the gravel is a loosely coherent sandy loam, containing terrestrial and aquatic shells of existing species, called in the Rhine valley by the technical name of *Loess*. From under the grauwacke a variety of unstratified rocks have been erupted, consisting of various kinds of trachyte and trachyte tuff, basalt, dolerite, and other modifications of trap; and in one place volcanic scoriæ. The main body of the Siebengebirge is composed of these unstratified rocks.

The structure of the Siebengebirge was long considered to be different in its character from that of any other group in Germany; and it is so with the exception of two analogous formations, the one in Nassau, near Montabaur, lately described by Stifft*; the other not far from Grätz in Styria, of which an account was published by M. von Buch† in 1820; and by Dr. Daubeny in 1826‡. It is remarkable that the trachyte of Nassau had not been previously examined by geologists: it is accompanied, as in the Siebengebirge, by trachyte tuff and phonolite, and rises in the midst of a basaltic district of vast extent, connected with that of the Westerwald. Professor Mitscherlich visited that part of Nassau in 1832, and I saw him just after he had been there. He described the trachyte as covering a space quite as great in extent as the Siebengebirge, but not forming such elevated hills, the trachyte outbursts rarely exceeding a very moderate elevation above the surface. In texture they very much resemble those of the Siebengebirge, and, like them, present various modifications of the constituent parts.

* *Geognostiche Beschreibung des Herzogthums Nassau*, 1831.

† *Ueber einige Berge der Trap Formation bei Grätz.*

‡ Description of Active and Extinct Volcanos.

I shall first describe the several formations in detail, in the following order: Grauwacke, Trachyte, Trachyte Tuff, Basalt, Brown-Coal Formation, Loess; and shall then point out their several relations to each other, drawing such conclusions as to their several ages, and the geological history of the district, as the facts appear to me to warrant.

Grauwacke.

This rock varies considerably in mineral character, sometimes occurring as a fine-grained clay slate, not distinguishable from that of Westmoreland; in others, as a coarse red sandstone, very like some beds of the old red sandstone of Herefordshire and Shropshire. Although I found no opportunities of forming a decided opinion on the subject, it is probable that the prevailing rock in the neighbourhood of the Siebengebirge belongs to the later periods of the grauwacke deposit. At Dottendorf, on the left bank of the Rhine, about two miles from Bonn, there are beds of it of a loose texture containing rounded pebbles of slate, with numerous vegetable impressions, which, in specimens, might be taken for a sandstone of the coal-measures. These impressions are too indistinct in form to enable one to pronounce upon their nature; they are black, and when exposed to heat the blackness disappears. Impressions of Terebratulæ and the stalks of Encrinites, although abundant in the grauwacke of the adjoining country, are not very common within this district. They are found in that near Rhöndorf, and in the neighbourhood of Unkel. In some places it contains anthracite; and I was informed by Mr. A. L. Sack that at Bruckhausen six different beds of it were found, one of which was a foot thick, but they were not continuous.

The strata are generally highly inclined, but they are found at all angles. There is neither uniformity in the strike nor in the dip, but the former is most generally from north-east to south-west, and the dip more frequently south than north. In the immediate neighbourhood of the Siebengebirge the strata are thrown up in all directions, which, at first sight, might be thought to be caused by the eruption of the volcanic matter; but there are great derangements of the grauwacke in the Eifel and Westerwald, at a distance from igneous rocks. Sudden variations in the strike and dip, the latter from vertical to horizontal, (if I may so speak of dip,) may be well observed between Unkel quarry and Remagen, and on the opposite side of the Rhine between Erpel and Orsberg.

The extent occupied by the grauwacke will be seen by an inspection of the accompanying Map. It flanks the volcanic region of the Siebengebirge on the east and south, and appears in detached spots on its western side, but it is wholly wanting on the north. On the left bank of the river it constitutes the ridge from Remagen to Rolandswerth, but it is partially covered by the brown-coal

formation and by loess between these places; and from Rolandseck northward, it is covered by the brown-coal formation, except in a few places on the eastern side of the elevated plateau that runs from Rolandseck in a north-west direction; as at Muffendorf, Friesdorf, Dottendorf, and Kessenich, in all which places it appears in highly inclined strata.

Trachyte.

There are several varieties of this rock. Glassy felspar is the chief ingredient in all, mixed with hornblende, occasionally augite, quartz, magnetic iron, and sometimes, but rarely, mica. Distinct crystals of glassy felspar, often of great size, are imbedded in the base of most of the varieties. The different aspects which the rock presents depend mainly on the felspar of the base being largely crystalline or small granular, upon the proportion of hornblende and size of its crystals, upon the size and proportion of the separate imbedded crystals of felspar and hornblende, and upon the colours imparted by the different states of the iron which enters into the composition of all. Some varieties are also produced by the felspar being decomposed.

The places where the trachyte can be studied to most advantage are on the Drachenfels, the Wolkenburg, and the Stenzelberg, especially the two latter, where there are extensive quarries. The trachyte of the Drachenfels is one of the most remarkable varieties: it is a gray stone, with a crystalline base of felspar, and minute crystals of hornblende, including separate crystals of felspar, often more than two inches long and an inch and a half in diameter. It has been for ages used as a building-stone, and is upon the whole very durable, except that the separate crystals of felspar are apt to fall out. The Cathedral of Cologne is built of it. The trachyte of the Stenzelberg contains more hornblende, and has few imbedded crystals of felspar; but those of hornblende often occur, and are sometimes of a great size. In some places there are portions of the rock, separated by sharp lines from the rest of the mass, of a dark fine-grained texture, so as to look like included fragments of basalt; but it is probable that they are fragments of slate, altered by the heat of the melted trachyte, as there are other similar portions about whose origin there can be no doubt, the slaty structure being quite distinct. In the quarry of the Stenzelberg a face of rock about sixty feet in height is exposed: it is divided by vertical rents into large tabular masses of irregular forms, and in some places they are rounded, standing out like the stems of gigantic trees, the rock separating into curved layers parallel to the axis, a tendency to exfoliation which is often observable in small specimens. This appearance has been particularly described by Professor Nöggerath*, and Professor Goldfuss, in his *Geognostiche Tafeln*, has given a print representing the face of the quarry at that time: it is now a good deal altered, and the appearance of exfoliation on the great scale is at present not so marked as it is in the print. The trachyte in the upper part of the quarry is vesicular, and it resembles the lava stream which is quarried for millstones at Nieder Mendig near the Laacher See; so much so, as to suggest the idea that the latter owes its origin to a melted trachyte. Mr. Lyell, who visited this place with me, remarked the great resemblance of the trachyte to the rock quarried above the Plateau de l'Aigle, not far from the baths of the Mont Dor in Auvergne. The trachyte of the Wolkenburg resembles that of the Stenzelberg, including, although more rarely, large separate crystals of hornblende, and occasionally large masses of quartz. It often contains

* *Das Gebirge in Rheinland-Westphalen*, iv. 359.

calcareous spar, lining cavities, and in well-defined crystals. Here, also, a lofty face of rock is exposed in the quarry, exhibiting the trachyte in large vertical tabular masses, without apparent cross joints, although these exist, as the rock separates easily into huge blocks by natural fissures. It is for the most part of a light fawn colour; but when the large masses are broken they show a bluish gray nucleus, such as is often seen in trap rocks. The one colour, however, does not always graduate into the other; on the contrary, there is sometimes a sharp line between them, and at the separation the trachyte is of a vitreous texture. I observed the same thing in the trachyte of the Keilsbrunnen quarry, with a tendency to globular decomposition. One of the most remarkable varieties of trachyte is that of the Perlen Hardt, on the eastern side of the group. I nowhere found such large imbedded crystals as here, but they are extremely brittle, and consequently good specimens are not easily obtained*. The base is much decomposed, the felspar being in some places changed into a bright red earth: it contains small yellow crystals of sphène. At the Rosenau there is a variety containing augite; I obtained a specimen at this place with a separate well-defined crystal of that mineral; and close to this spot I found a sudden change into a variety with large imbedded crystals of felspar, like that of the Drachenfels, a circumstance which, like many others, shows under how many different forms the same materials may issue from a volcanic focus. At the Klein Rosenau there occurs a variety of a light gray colour, very compact, with a conchoidal fracture and ringing sound, a phonolite, composed of felspar and quartz, without any hornblende or other ingredient; and it passes into another kind of a light fawn colour, still more compact, in which the quartz predominates almost to the exclusion of the felspar, being infusible, while the gray variety is readily acted upon by the blowpipe: the latter is in some places of a bright pale green, apparently from an admixture of iron, and contains chalcedony, hyalite, and veins of ferruginous opal†.

The Hummerich, the Mittelberg, and the Bruder-Kunzberg are three conical hills, which rise out of an elevated plateau of grauwacke at some distance to the south of the main group of the Siebengebirge. They are composed of trachyte, but of a kind bearing a strong resemblance to some varieties of trap, particularly that of the Mittelberg and Bruder-Kunzberg. It is of a gray colour, has a much smaller proportion of distinct crystals of felspar and hornblende, and has somewhat of a foliaceous structure. At the Hummerich it is rudely columnar, and has a tendency to globular decomposition: at the foot of the same hill it has the character of an amygdaloid.

The affinity between trachyte and the trap family has been pointed out by many geologists; long ago by M. von Buch in his admirable essay on Trap Porphyry‡. In the Siebengebirge it would be easy to form a suite of specimens, showing a gradation from a white trachyte to a compact black basalt. The analogy is further seen by the columnar form and tendency to globular de-

* Lavas, which probably belong to a much more modern period than these rocks, contain felspar crystals of great size. In his description of the Ponza Isles, Mr. Poulett Scrope says, "I met "with some felspar crystals nearly three inches in diameter, and these are accompanied by augite, "bearing the same proportion to them in size as the ordinary minute grains to the common-sized "felspar."—Geological Transactions, Second Series, vol. ii. p. 215.

† Mr. Poulett Scrope in the same Memoir, describes a *siliceous trachyte*, which appears from the description to be very similar to the rock found at the Klein Rosenau.—Geological Transactions, Second Series, vol. ii. pp. 201, 208, 214, 229.

‡ Transactions of the Royal Academy of Berlin, 1812.

composition. Near the Thier Garten, north of the Stenzelberg, there is a variety of trachyte scarcely distinguishable from the base of an earthy amygdaloid; and I found a block at the foot of the Drachenfels, of a green colour, very like some kinds of serpentine. Nor is this intimate connexion between these two classes of unstratified rocks different from what might naturally have been expected to happen, for the materials of both exist in the same spot; variations in the proportions of these not very numerous ingredients, in the degrees of heat to which they were exposed, in the circumstances under which they cooled, would perhaps account for all the shades of difference we meet with. M. Von Buch states in the memoir above quoted, that when trachyte passes into a black substance, the felspar and hornblende have disappeared, and olivine and augite have taken their places. Much light has been thrown on this subject by the interesting experiments of Mr. G. Rose*, who has shown how intimately hornblende and augite are connected: he obtained artificial crystals of the forms of augite by fusing hornblende; and he conceives that hornblende may be formed by slow, and augite by rapid cooling. Such gradations show how necessary it is to be cautious in drawing geological inferences from mere mineralogical variations, and that in giving new names to rocks merely on account of such differences, much confusion and error may be introduced. Notwithstanding, however, this connexion between the trachyte and basalt of this district, the basalt appears to have been, if not entirely, at least in great part, erupted at a distinct and later period, and I have not discovered any evidence of trachyte having been again ejected after the basalt had begun to flow†.

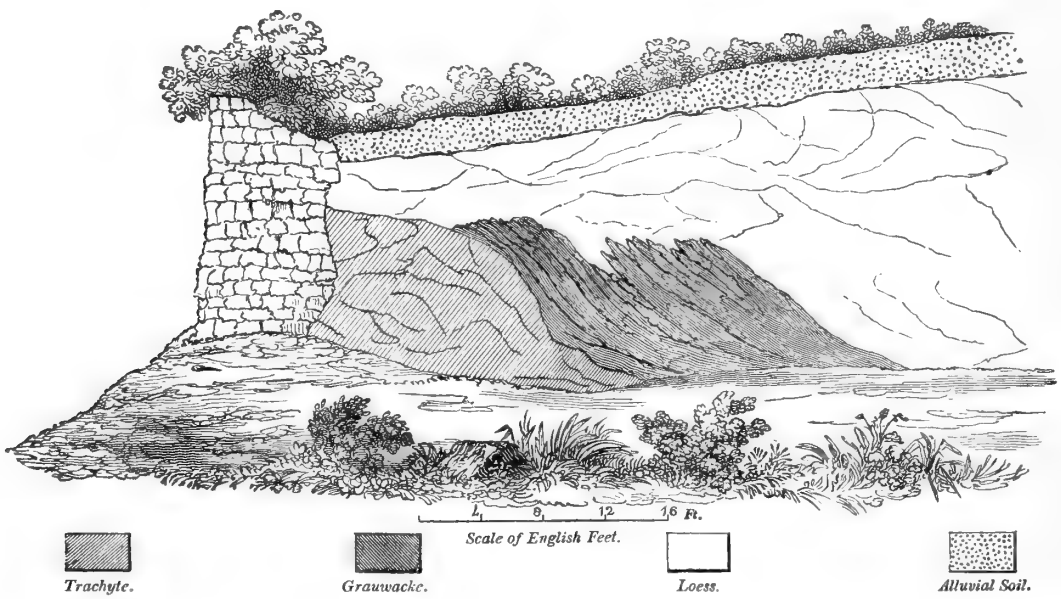
There is only one place where I have seen the trachyte in the form of a dike or vein, and I have not been able to learn that it is so met with in any other spot. This dike crosses the road from the Löwenburg Tränke to the Perlen Hardt. It is about five feet wide, and is much decomposed, but the fresher parts resemble the trachyte of the Perlen Hardt. It traverses a trachyte tuff, containing hard masses of trachyte and fragments of slate.

* Leonhard and Bronn's *Jahrbuch für Mineralogie*, &c., 1832, p. 237.

† Among the volcanic rocks of the Siebengebirge are varieties whose constituent parts are as largely crystalline as any granites that have been met with. Von Buch states that in several places in the neighbourhood of Clermont and Puy de Dome, a transition from granite into trachyte may be traced, and thus we have the gradation extended from granite to basalt. Dr. Hibbert describes a gradual transition from basalt into granite in the Shetland Islands. (Brewster's Edinburgh Journal of Science, i. 107.) Speaking with Professor Mitscherlich about the large imbedded crystals of the Drachenfels and Perlen Hardt, he remarked to me, that in a mass which is only viscid, crystals will be formed, but that it requires a very long time; that felspar becomes viscid at a comparatively moderate heat, but that it requires a very high temperature to make it flow.

The substances which in Hungary and Central France accompany trachyte, viz. pitchstone, obsidian, pearlstone, and pumice, do not occur in the Siebengebirge, if we except some portions of the latter that are met with occasionally in the trachyte tuff. It has in no instance flowed as a stream, nor do any of the hills in the Siebengebirge show any signs of a crater.

The ground is so covered with vegetation that it is very rarely that the different rocks can be seen in contact. In one place only have I been able to discover the trachyte and grauwacke together: this is behind the village of Rhöndorf, at the Bruckersberg, where trachyte rises under grauwacke strata, inclined at a high angle, bent and broken, and both are covered by a thick unstratified mass of loess. The trachyte is much decomposed, but at a short distance it is tolerably fresh.



When the water in the Rhine is low, trachyte rocks may be seen stretching from the foot of the Drachenfels a considerable way across the river; but it has not been found in any part of this district on the left bank of the Rhine, except at Borkum, about three miles west by south of Mehlem: there it is of a grayish white colour, is composed of white felspar and minute portions of green hornblende, with imbedded crystals of glassy felspar. It forms a small hill, surrounded on all sides by grauwacke slate, but the junction cannot be seen*.

Trachyte Tuff.

A considerable part of the Siebengebirge is covered with a tuff† consisting of angular fragments of trachyte, generally in an earthy state, especially as

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* Von Oeynhausen and Von Dechen, in *Hertha*, xii. 432.

† I adopt the term *trachyte tuff* in preference to that of *conglomerate*, by which it is usually called by the German geologists, because, in England, conglomerate would generally be understood to mean a congeries of water-worn fragments of various substances.

regards the felspar, for the most part loosely aggregated, but sometimes so compact as to be quarried for various economical purposes. The fragments are usually small, seldom larger than hazel-nuts or small beans, and sometimes so fine, that when the stone is white and compact, it is very like a coarse chalk. It occurs grayish white, yellow, and brown of various tints, and sometimes of a reddish colour. It frequently contains masses or balls of hard trachyte, varying in diameter from a few inches to two feet and upwards, and fragments of slate, usually angular, but sometimes rounded. Except in one situation, which I shall afterwards mention, I never found any basalt fragments in the tuff, an important fact as regards the history of these volcanic regions. They were formerly stated to have occurred, but later observations have shown that what was taken for basalt is a very compact black slate. I searched for basalt in those places where it was said to occur, but never found any.

The trachyte tuff generally occupies the intervening valleys, and is found at considerable elevations, but none of the higher summits are composed of it: they are either of trachyte or basalt. Its extent and mode of surrounding the trachytic and basaltic hills will be best understood by an inspection of the Map, but I shall mention some of the spots where it may be most distinctly seen.

The road from Königswinter into the Wintermühlen-thal goes across the extremity of a ridge, which descends from the Drachenfels, apparently wholly composed of trachyte tuff, and at a place called the Hölle it is cut through to the depth of forty feet. Here it is of a brown colour, and seems to contain much iron. It is traversed in all directions by lines like the decomposing crusts of two surfaces united, which sometimes give a false notion of stratification: in many places it is decomposed in concentric layers, like basalt, and it contains numerous masses of trachyte and slate. It is traversed by basalt dikes, which will be afterwards described. A tuff similar to this occurs between the Lohrberg and Scheerkopf, where it is traversed by the trachyte dike, mentioned p. 439, and it is here at an elevation of about 900 feet. The tuff in these two places is different from any that occurs elsewhere in the district. After passing the Hölle, and arriving at Quegstein, at the entrance of the valley, a white, very loosely coherent tuff, including fragments of slate, rests on a compact sandstone of the brown-coal formation, and is covered by loess: specimens may be obtained of the junction of the tuff and sandstone. In the museum of the University of Bonn there are specimens of tuff from this place with impressions of the leaves of trees similar to those which are found in the brown-coal formation. In the immediate vicinity of this spot there was a knoll of basalt, which contained fragments of slate converted into jasper, of which several specimens may be seen in the museum; but the hard rock has been entirely removed for mending the roads. Higher up the valley, the tuff, preserving its white colour, becomes more compact, and at the Ofenkulenberg, a ridge descending from the Wolkenburg, it is quarried. It is much used for building ovens, from its property of resisting heat, and is thence called *Backofenstein*; and from being easily worked, masses are hollowed out to form troughs. In the road leading to the quarry it is traversed by a dike of basalt; and Mr. Nöggerath* says, that at this place impressions of leaves have been found in the tuff. In the Keilsbrunnen Steig, near the Ofenkulenberg, a similar tuff is traversed by dikes of basalt.

* *Rheinland-Westphalen*, i. 135.

The trachyte tuff is well seen in the Haisterbacher-thal, the other great valley which runs up into the Siebengebirge from Ober-Dollendorf, to the Stenzelberg and to Haisterbacherroth. At the Langenberg it is loosely coherent, white, and pale red, contains much pumice, fragments of slate; and portions of *wood*, in a soft state and of a brown colour, are not uncommon. Small crystals of glassy felspar may be picked out of the earthy base, and the ruts in the road are often coated with magnetic iron-sand, left by the rain that has washed the tuff. It contains numerous masses of trachyte, many of which are quite fresh, and resemble those of the Drachenfels, Rosenau and Stenzelberg; others unlike any found *in situ*. The tuff in this place lies in beds which are nearly horizontal, but it exhibits that partial and irregular deviation from horizontality in short distances, so often seen in sections of beds of gravel where there are alternations of sand, indicating the deposition of the tuff to have taken place under the surface of water. Ascending the valley at the foot of the Wirlberg to the Stenzelberg Kreuz, another section of the tuff is seen covered by loess; and Professor Nöggerath states* that the tuff here was traversed by a vein of opal jasper from two to three inches thick, and nearly vertical, very like the wood opal of Hungary: it has long since been carried all away. Immediately above Ober Cassel a tuff is found which differs considerably from any other in the district I have met with, in as much as it contains fragments of basalt and scoriæ, together with balls of clay ironstone. From its situation it is not improbable that this may be an after deposit of trachyte tuff, along with clay of the brown-coal formation.

Behind the village of Honnef a small knoll, called the Schwarzenerdenkopf, is formed of a conglomerate or rather breccia, to which I have found nothing like in any other part of the district. It contains fragments of trachyte of different kinds, scoriaceous basalt, compact basalt, quartz, crystals of felspar and hornblende. It is surrounded on all sides by grauwacke, and is of very limited extent. It is altogether a very singular occurrence, and not very intelligible as to its origin.

Between the villages of Dambruch and Rott, on the northern slope of the Siebengebirge, considerably within the region of the brown-coal formation, and four miles from the nearest point where trachyte occurs, there are distinct beds of trachyte tuff lying between beds of clay and clay ironstone. The same association of tuff with the brown-coal formation is found at Scheurn, Utweiler, and Oehlinghoven. It is generally composed of smaller fragments than the tuff nearer to the trachyte, but it contains masses of fresh hard trachyte. At Scheurn it contains impressions of the leaves of trees, similar to those found in the brown-coal formation.

The only spot on the left bank of the Rhine where I have found trachyte tuff is in a lane behind the village of Muffendorf, between that place and Godesberg; it is very similar to that near the Drachenfels, and contains large masses of trachyte†.

It has been remarked by some who have described the Siebengebirge, that the trachyte tuff always corresponds in composition with the trachyte nearest to it, as if it were derived from a disintegrated trachyte, and were thus a recomposed rock. I have looked for this correspondence of structure, but could never satisfy myself that such is the fact. In the first place the tuff is, in almost every case, in too earthy a state to enable one to say of what particular species of trachyte it is composed; and in the next place, it occurs generally surrounded by trachytes of various kinds; and lastly, the masses or

* *Rheinland-Westphalen*, i. 139.

† See Appendix III. p. 472.

balls of trachyte which it contains are very often entirely different from any variety that now exists *en masse*. In addition to all these objections to its being derived from preexisting trachyte, I think there is every reason to suppose that the ejection of the tuff preceded that of the solid trachyte, just as in existing volcanos showers of ashes often precede streams of lava.

Basalt.

Although all the rocks I am about to describe under this head do not strictly correspond in mineralogical character with the black compact substance to which the term is usually applied, I shall not convey any erroneous idea by employing it, as by far the greater proportion of the trap rocks of the district are true basalt, characterized by the presence of olivine, and the rest have a great resemblance to it.

Basalt occurs in different parts of the district on both sides of the Rhine. In the Siebengebirge it forms entire hills, and dikes of it traverse grauwacke, trachyte, and trachyte tuff; it is also associated with the beds of the brown coal formation. The three highest hills in the district are composed of it, viz. the Düsberg near Linz, the Oehlberg, and the Löwenburg in the Siebengebirge; and, by a reference to the Table of Heights in the Appendix, it will be seen that it constitutes one half of the separate hills in the group. The extent of their united surfaces is also fully equal to that occupied by trachyte.

There are two important differences as regards the manner in which the two classes of rocks have been ejected: the trachyte, except in a single instance, is not found in veins traversing other rocks, and the basalt is never associated with basaltic tuff except at Siegburg, to be afterwards described, and that hill is not within the Siebengebirge group.

The summit of the Löwenburg is composed of a rock that would be called dolerite by most geologists, its constituent parts, augite and felspar, being in much larger grains than in basalt: it contains magnetic pyrites, and it separates in some places into slender irregular columns.

The upper part of the Oehlberg is a close-grained black basalt in large tabular or rudely columnar masses, highly magnetic, and possessing polarity; it contains in some places numerous reddish brown grains, which are probably hyacinth, as that mineral is not unfrequently met with in the basalt of the district: among the specimens which accompany this paper is one from Papelsberg near Ober-Cassel, with a well-defined crystal of hyacinth*. The ridge between Ober-Cassel and Ramersdorf is wholly composed of basalt, containing much common calcareous spar and arragonite, but no zeolite, a substance which seems to be of very rare occurrence in the Siebengebirge. Numerous quarries have been opened in this ridge; in the most considerable of them the rock has

* Sassenberg, the intelligent guide of the Siebengebirge at Ober-Dollendorf, told me in July 1833 that a specimen of basalt had been found in the quarry at Unkel containing sapphire.

the remarkable appearance of a gigantic globular concretion, an ellipsoid, the shorter axis of which is at least seventy feet, composed of concentric layers. Professor Nöggerath* has described this spot; and although by the operations of quarrying the appearances are a good deal altered since his drawing was made, the concentric arrangement of the rock is quite distinct. In a quarry north of this the basalt is split into tabular masses like stratification; and these again into smaller portions by cross rents, so that the face of the rock looks like a dry-built wall of squared stones, an appearance not at all uncommon in modern lavas. In a quarry under Fovaux's Häuschen, a little further north, the basalt presents the appearance of a pile of globular concretions so squeezed together as to assume the form of flattened lenticular masses.

In the southern part of the district the sharp cone which rises from the grauwacke plateau above Honnef, called the Leyberg, is composed of rudely columnar basalt; and between it and Linz are four other conspicuous hills, rising in a like manner from the grauwacke; the Gross Düsberg, 1325 feet above the Rhine, the Klein Düsberg, the Hummelskopf, and the Mendenberg, all composed of basalt. On approaching the Mendenberg from Erpel or Linz, one is surprised to see the quantity of fragments of the most regular slender basaltic columns, which are applied to all sorts of purposes, as building-stones; pig-styes are constructed of pillars which would be prized as beautiful specimens in a public museum. The quarry from which these are procured is situated immediately under the summit of the Mendenberg; it forms at present an oval space of about fifty feet by thirty, the entrance to which is by a narrow passage, and it is surrounded by walls twenty feet high, of the most regular slender columns, standing nearly erect, and packed close together like the cells of a honeycomb, but easily separable and without cross joints, so that single columns are sometimes obtained of the whole height: I saw one lying on the ground, a hexagon of nine inches diameter and sixteen feet long. The most regular columns are pentagons and hexagons; in these the angles are very sharp. It is a very compact black basalt, which breaks into very sharp fragments that ring like glass, and contains few imbedded minerals: I obtained, however, a good specimen of slender prismatic mesotype. The ends of the columns reach the surface, and are not covered by amorphous basalt; but they are an inferior bed, for higher up, at the very summit, there is a mass of columns less regular in form, lying in an inclined position, and detached from each other. Such is the profusion of basaltic columns in this neighbourhood, that the walls of the town of Linz are wholly built of them, laid on their sides, with the ends projecting outwards; and the streets are paved with the smaller columns set on end, a miniature representation of the Giant's Causeway. The walls of Bonn and Cologne are in the same way built of fragments of basaltic columns laid with brick; and the posts by the sides of the roads and streets in this part of the country are generally made of the same ready-shaped stones.

All round Linz basalt breaks out from the grauwacke at detached points. One of the most considerable of these eruptions is the Erpeler Lei, which rises to a very considerable height from the edge of the river. These basalt knolls are of very frequent occurrence towards the east and south-east of this district, and they form a continuation of the eruptions around Siegen, in the Westerwald and near Frankfurt; and these are connected with the greater masses of the Vogelgebirge Rhöngebirge, and Habichtwald. It breaks out, too, at several detached points on the left bank of the Rhine within this district. The Landskron in the lower part of the Ahr valley, a hill about 800 feet high, is composed of grauwacke for two thirds of its height; but the upper part is basalt, showing some tolerably regular jointed columns. Opposite to the town of Unkel a considerable face of rock is exposed in an extensive quarry: here the whole mass of basalt is columnar, the

* *Rheinland-Westphalen*, ii. 250. See also Dr. Daubeny on Volcanos, p. 67.

columns lying in an inclined position, and separated from each other as if there had been an intermediate part reduced to an earthy state by decomposition. The basalt itself is very fresh, and contains many simple minerals, especially olivine in rounded granular masses, sometimes as large as a turkey's egg, calcareous spar, hornblende, mesotype, hyacinth, and magnetic iron. In the upper part of the quarry there is a basalt conglomerate which includes fragments of wood, and above that a pretty thick bed of loess. When the water in the Rhine is low the columnar basalt is seen extending a considerable way into the stream, and before a great part of it was removed it rendered the navigation here difficult and dangerous. Eruptions of columnar basalt may also be seen at Rolandseck, at Dechelsberg near Nieder Bachem, at Lühnsberg near Muffendorf, and near Kessenich; and the conical hill of Godesberg, which, crowned with its ruined castle, forms so conspicuous a feature in the landscapes of this neighbourhood, is composed of the same rock.

Basalt Dikes.

These are of frequent occurrence in the Siebengebirge.

In the Keilsbrunnen quarry, not far from the Löwenburg, a dike of amygdaloidal trap, about twelve feet thick, traverses trachyte; and one traversing the trachyte tuff in the immediate neighbourhood, from its composition and direction, seems to be a prolongation of the same. Not far from hence, at the Löwenburg Tränke, the trachyte is traversed by a dike of amygdaloidal trap about two feet wide, the trachyte being much decomposed. In the lane leading from Königswinter to the Keilsbrunnen quarry, between the Hirschberg and Wolkenburg, the trachyte tuff is traversed by four dikes in a space of about seventy-five feet. They are narrow, but their dimensions and their relations to the substance they cut through cannot be well seen from the covering of soil. Near the Stenzelberg Kreuz the trachyte tuff is cut by a dike which probably is connected with the basaltic hill, the Wirlberg, close by, and which probably has also sent out the dike in the opposite direction, which is seen near the Thier Garten. In a road leading over the hills due east of Honnef, near Steinsbusch, a dike of basalt cuts the grauwacke strata; there is no change produced in the latter either in regard to disturbance of the regularity of the stratification or the texture of the stone; but at no great distance, at the Goldnen Kistchen, a mass of basalt in contact with the grauwacke changes it into a hard substance like jasper, which splits into prismatic fragments.

In the Königswinter valley, and in the road to the Ofenkulenberg quarry, and not far from it, a white trachyte tuff is traversed by a trap dike about six feet wide; the tuff is considerably hardened at and near the junction, and splits into prismatic fragments. The dike is a dark amygdaloidal basalt with olivine; but there seems to have been an intermixture with the tuff towards the sides, where it is so changed as scarcely to be recognisable from basalt in detached specimens. Where it is of a dark colour it separates into thin plates like a coarse slate, parallel to the direction of the dike. The tuff in the Königswinter Hölle, described p. 441. is traversed by two dikes of about two feet in width, which intersect each other; the one being thrown considerably out of its direction by the other, but the point of intersection is concealed by the road. The substance of these dikes is so much decomposed that it would be impossible to recognise them for basalt except by their resemblance to what occurs in other instances, where the rock is partly fresh and partly decomposed; indeed one of the dikes is changed into a substance very like a dun-coloured friable sandstone. Besides these two dikes there are two others in the same situation, but they do not present anything requiring particular notice.

One of the most remarkable volcanic eruptions of this neighbourhood occurs at Siegburg, a small town in the northern part of the district. The small river Sieg winds through an extensive alluvial plain, and in the midst of this, entirely detached from the adjoining hills, three conical eminences rise up, one of them quite insulated, the other two connected together by a low ridge. At the foot of the insulated cone, which is 211 feet high, the town of Siegburg is situated, and on its summit there is a vast building, formerly a monastery, now a public Lunatic Asylum, which forms a very conspicuous object for many miles round. The principal mass of these three hills is a tuff of a yellowish brown colour, in some places compact, but more usually of a loose texture; in point of structure very like trachyte tuff, but substituting the constituent parts of basalt for trachyte as the material; and it is used for similar purposes, viz. the construction of ovens and fireplaces. Its component parts are for the most part decomposed basalt, but sometimes the fragments are fresh; many are in the state of scoriæ, and there are numerous fragments of grauwacke slate. It is often penetrated by calcareous spar, seemingly introduced by subsequent infiltration; and it contains numerous fragments of dicotyledonous wood, generally brown like lignite, sometimes fossilized by calcareous spar, at others highly charged with iron; balls of clay ironstone are not unfrequent. Mr. Lyell, who visited this spot with me, remarked the great resemblance of this tuff to the volcanic tuff of the Phlegræan Fields and of Ischia. The two connected hills are called the Grimprich and Wolsberg, and are 189 and 230 feet high. From the former stands out a mass of basalt at the summit, a part of a dike from the sides of which the tuff has been washed away, portions of it being still left adhering; the main part of the dike is a compact black basalt, but towards the sides it becomes scoriform; it may be traced to the bottom of the hill. On the south-east side the tuff lies in beds dipping from the hill, that is, with a slope nearly parallel to its present surface. The basalt contains nests of arragonite in well-defined crystals. In the Wolsberg there are large quarries where the tuff may be seen in all its varieties, being sometimes so hard as to require to be blasted. On the south side, and just above the Sieg, it is traversed by a double dike of basalt, each branch about a foot wide, the tuff between being very different from that on the outside, appearing like cinders that had run together, part being in a twisted form, as is often seen when a viscid ropy stream of lava has cooled; the basalt of the dikes is also scoriform. No place can show in a more distinct manner the similarity of an undoubted lava to basalt occurring in situations where none of the usual appearances of active volcanos exist; for the basalt of these two cones could not

be distinguished in specimens from the Rowley Rag of Staffordshire, or the Castle Rock of Edinburgh.

The only remaining point of volcanic eruption which I have to notice is the Roderberg, a hill above the village of Mehlem, on the left bank of the Rhine. From a distance, and even near at hand, one would not suspect that the hill had anything volcanic in its nature; it is not conical, but looks like a smooth rounded prolongation of the adjoining hills that belong to the brown-coal formation. But at the beginning of the ascent from Mehlem loose black cinders appear, and on arriving at the summit there is found a circular depression of about a hundred feet deep, and a quarter of a mile in diameter, once the crater of a volcano, but now occupied by corn-fields surrounding a farm-house. It is on the north and north-east side chiefly that the volcanic materials are seen, for in the ascent from Nieder Bachem there are few traces of them, till one comes to the edge of the crater, even although the road is cut several feet deep into the hill in some places. On the north and north-east the edge of the crater is composed of a spongy scoriaceous rock, with marks of fusion, identical with the productions of active volcanos. At the south-west side of the crater, however, grauwacke appears, but whether *in situ* or in detached blocks it is difficult to determine; it is of that brighter red colour from oxidation of iron which is produced when a portion of grauwacke is exposed to a strong heat. Upon this lies a yellow gravel, the same as that which covers the brown-coal formation throughout the district, and containing no fragments of volcanic matter; and upon the gravel lies a black tufaceous semi-indurated substance, disposed in layers which slope outwards from the crater*.

Brown-Coal Formation.

This formation consists of an assemblage of beds of siliceous sand, sandstone, quartzose conglomerate, clay of different qualities, clay ironstone in layers and detached masses in the clay, and of lignite of various qualities, in distinct beds and intermixed with the clay.

It occupies a great extent of country on both sides of the Rhine. On the right bank it covers the northern slope of the Siebengebirge, as it falls to the plain through which the Sieg flows, occupying an area of about seven miles from east to west, and five from north to south. It occurs again north of the Sieg, in detached spots along the sides of the hills forming the eastern boundary of the Rhine valley, as far as the immediate vicinity of Bensberg, nine miles east of Cologne. On the left bank of the river it forms a long broad ridge of low hills, or rather plateau, lying between the valleys of the Rhine and the Erft, from the town of Meckenheim, nine miles south-west of Bonn,

* See Appendix IV. p. 472.

to the south of the town of Bergheim, between Cologne and Juliers, a stretch of about thirty miles; and Professor Nöggerath informs me that he has traced the lignite beds at intervals from Bergheim to Aix la Chapelle. The breadth of the plateau varies from three to five miles. Its greatest elevation is about 200 feet above the plain on the eastern side; and from the foot of the plateau near Brühl to the Rhine, a distance of about five miles, there is a fall of fifty feet*. These two districts, on the right and left banks of the Rhine, are the chief deposits; but the formation occurs at several places further south, on both sides of the river, and also *within* the volcanic regions of the Siebengebirge and Lower Eifel.

A. *The Siliceous Deposits.*

The lowest member of the formation seems to be the loose siliceous sand; with this is associated, and generally covering it, a sandstone of various degrees of coherence, sometimes so friable as to be easily rubbed between the fingers, at others as compact as a granular quartz rock. At Tänzchen and Quegstein, in the valley above Königswinter, all these varieties may be seen together. Here also are found thick beds of a quartzose conglomerate, the pebbles of which are for the most part small, but sometimes as large as a pigeon's egg, and so associated with the fine-grained quartzose rock, that specimens may be obtained of both united, sometimes showing a gradual transition from the coarse to the fine, at others a sharp line of separation. In specimens no one could distinguish this sandstone conglomerate of fresh-water formation from rocks of constant occurrence in the grauwacke and older secondary strata. The conglomerate is traversed by yellow and brown semi-opal, which occasionally assumes the mammillary structure of chalcedony, and in which traces of vegetable structure may be detected.

In the neighbourhood of Rott and Geistingen, on the right bank of the Rhine due east of Bonn, there are found, associated with a thin leafy bituminous lignite which has obtained the name of *Papierkohle* (*Paper-coal*), laminæ of a flinty substance, seldom above an inch thick, and usually accompanied with thin friable siliceous plates, earthy, and bearing some resemblance to the Polierschiefer that is found in the brown-coal formation of the Habichtwald. Between the plates of the Papierkohle siliceous concretions, of the form and size of beans, are sometimes found.

B. *The Argillaceous Deposits.*

These consist of beds of clay of various qualities and colours, according to which they are used for making bricks, tiles, and pottery; and some is sent into Holland for making tobacco-pipes. In many places the clay is much

* Von Dechen, *Beschreibung des Kuhlen und Tummelbau in dem Brühler Braunkohlenrevier*, in Karsten's *Archiv.*, vol. iii. 1831.

mixed with earthy lignite, is in many places very pyritous, and when that is the case, works have been established for the manufacture of alum, as at Friesdorf on the left bank, and Holtorf on the right bank of the Rhine, both near Bonn. The clay, intermixed with earthy lignite, which also contains pyrites, is piled up in lumps, forming heaps of many yards in length; and after being for some time exposed to air and moisture, decomposition takes place, evolving much heat; sulphate of iron and sulphuric acid are formed, which last unites with the alumine of the clay, and by repeated solutions and evaporations, and the addition of potash, crystallized alum is obtained in the usual way. This spontaneous heating, often extending to inflammation, sometimes takes place in the pits where the brown coal is worked. Between the layers of the alum slate crystals of gypsum are often found, and large detached crystals of gypsum occur in the clay, as in the London clay, in both cases most probably produced by the decomposition of pyrites.

Clay ironstone is of frequent occurrence in the clay, both in the form of layers and in detached lenticular and irregular masses. In the neighbourhood of Rott thirteen different layers were found, varying from an inch to a foot in thickness, and making together nine and a half feet of ironstone*. Massive portions of crystalline spathose iron have been found at Scheurn near Rott.

C. *The Brown-Coal or Lignite.*

This is found in various states.

a. A dark brown or black earthy substance, friable, sometimes pulverulent, generally occupying the upper part of the lignite beds, and rarely showing a stratified structure.

b. A concreted mass, in which fragments of wood and leaves are visible, with a mixture of earthy matter.

c. Wood in different stages of bituminization, of all shades of colour, from light brown to black, and the latter sometimes approaching to the nature of jet.

d. Papierkohle, highly bituminous, burning with a bright flame, leaving a white ash, separating readily into leaves as thin as writing-paper; a deposit of finely comminuted vegetable matter and earth.

The wood is generally in fragments of inconsiderable size; but sometimes large stems of trees are found, and if lying horizontal, as they usually are, very often flattened. Trees have been met with in an upright position with their roots attached, and the stem passing through different beds, into which the

* Nöggerath, *Das Gebirge in Rheinland-Westphalen*, iv. 388.

lignite deposit is separable. Professor Nöggerath mentions* two instances at Friesdorf; in the one the tree was seven feet in diameter, and from the beds it penetrated must have been about ten feet high; in the other the tree was eleven feet thick, but how high could not be ascertained. At Zisselsmaar, on the western side of the plateau, an upright mass of root and stem, of four feet in length, was found†. I do not, however, mention these instances as any proof of the trees being in the situation in which they grew, for if they were floated, the heavy root might keep them in an erect position, and the rarity of the occurrence is a strong presumption against the idea.

The wood is sometimes so fresh, so little changed, as to have been used at Viernich for timbers in the mines‡. Pyrites is of frequent occurrence in all the beds; and sometimes, as at Friesdorf and Holtorf, wood, in which the texture is preserved, is highly charged with a granular carbonate of iron. A specimen which accompanies this paper is a portion of a tree which I found in a thick bed of lignite at Friesdorf; it was about four feet long, and a foot and a half in diameter. The interior was converted into carbonate of iron to the almost total disappearance of the woody texture, but this last was still entire on the outside, where the iron was in the state of a yellow oxide. I have mentioned, p. 446, that I found a portion of wood highly charged with oxide of iron in the basaltic tuff of Siegburg; and it is important to remark, with reference to the relative age of the brown-coal formation, and the volcanic eruption of Siegburg, that in addition to this fact I found a specimen of bituminized wood in the basaltic tuff identical in appearance with a specimen which I obtained from the brown-coal beds at Geistinger Busch.

M. Von Dechen mentions that at Lieblar a lignite is found with a thin powdery coating of amber. From the smell which this coal gives out when burnt, the workmen call it *edeler Weihrauch*, frankincense.

D. *Organic Remains of the Brown-Coal Formation.*

These consist of vegetables, fish, insects, and reptiles: no shells of any sort have ever been found, except in one particular spot, which I shall afterwards notice; and no remains of quadrupeds, except in two very doubtful cases§.

a. *Remains of Vegetables.*

The brown-coal or lignite beds consist of wood and of leaves, and wood and impressions of leaves are also found in the siliceous and argillaceous beds of the formation. As the woods occur in

* *Beschreibung der Braunkohlen Ablagerung auf dem Putzberge*, in Von Moll's *Jahrbuch*, vol. iii. Nuremberg, 1815.

† Von Dechen, *uti supra*. ‡ Ibid. § See Appendix V. p. 473.

broken masses to which leaves are never attached, no decision can be pronounced as to the general to which they belong more exact than that of resemblance. Faujas St. Fond, in a description of a visit he made to the brown-coal mines at Lieblar, published in 1802, says that he obtained specimens of fruits found in the brown coal which Jussieu and other eminent botanists pronounced to belong to the palm tribe*. The impressions of leaves are most distinct in the Papierkohle, the sandstone and clay ironstone, and the leaves belonged, doubtless, to the stems which are associated with them.

In sinking a pit some years ago in the clay at Bruch near Ober Cassel, there was found a bed of fragments of silicified wood four feet thick. Professor Nöggerath made a very close examination of an extensive suite of specimens of the wood from this place, in the possession of Professor Leonhard of Heidelberg, with Mr. C. Bernhard Cotta, the author of an excellent work on fossil woods†, and the result was, that without a single exception they were all dicotyledonous. There exist, however, in the museum of the University of Bonn, two specimens from this place of a doubtful character. They are from three to four inches long, and about an inch and a half thick, and are silicified. They were long imagined to be fir tops, but Professor Nees von Esenbeck, Sen., who at the request of Professor Nöggerath examined them with great care, was of opinion that they are most probably portions of the root of a species of Fern‡. Among the specimens I obtained from this place is one in which the silicified woody fibres separate like some kinds of glassy actinolite; this variety is not uncommon; some are found passing into the state of semi-opal. At Alter Roth, near Haisterbach, I found in a friable sandstone a portion of a branch of a tree, which is remarkable in this respect, that while the form of the branch with a knot in it is perfectly preserved, the substance of the wood has been replaced, not as in the other instances by silica in a state of minute division, but by a somewhat coarse quartzose sand.

It does not appear that the vegetable remains contained in the brown-coal formation of this district have as yet been described by any botanist of acknowledged authority. My friend Professor Lindley has been so kind as to examine the specimens I have sent in illustration of this paper, and the following communication from him contains the result of that examination.

"The principal part of the impressions of leaves is in a state which renders it impossible to de-
"termine, with any certainty, the nature of the plants to which they have belonged. They consist
"generally of casts of portions of dicotyledonous foliage, of so common an appearance that no one
"could have determined them with precision, even if they had been newly gathered and possessed
"of all those characters of texture, surface, colour, and odour, by which a botanist would be
"obliged, in the case of such fragments, to form his opinion.

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* "On trouve quelquefois dans les mines de terre d'Ombre de Liblar, des fruits qui ont au pre-
"mier aspect la forme des noix ordinaires enveloppées de leur brou, mais en les examinant avec
"attentions l'on voit qu'ils en diffèrent totalement. Les botanistes les plus exercés, tels que de
"Jussieu, Desfontaines, Thouin, après avoir examiné et comparé ces fruits ont trouvé qu'ils avoient
"un très grand rapport avec les noix du palmier Areca. Ils n'ont pas cru devoir affirmer que
"ces fruits fussent directement ceux de l'Areca, mais ils ont une opinion unanime qu'ils ont ap-
"partenus à des arbres du genre palmier."—*Annales du Museum d'Hist. Nat.* i. 459.

† *Die Dendrolithen in Bezichung auf ihren inneren Bau.* Dresden, 1832. 4to.

‡ M. Alex. Brongniart says, in treating of lignite, in 1823, "On n'y cite encore aucune fougère
"evidente, ni aucune des feuilles ou tiges des plantes de cette même famille."—*Dict. des Sciences Naturelles*, vol. xxvi. p. 360.

"Among them are, however, three species, the existence of which is sufficient to determine with "certainty the relative age of the formation; and, with great probability, the nature of the climate "of the North of Germany at the time of their deposit.

"Messrs. Murchison and Lyell found in the tertiary formation of Aix in Provence, remains of a "Cinnamon, and of a kind of coniferous plant called Podocarpus, figures of which are given in the "Edinburgh New Philosophical Journal for 1829, p. 298. Both of these occur in the present col- "lection, and along with them distinct traces of the leaf of some kind of Palm, which was also met "with in the deposit at Aix.

"The Cinnamon I formerly thought identical with *C. dulce*, a species now inhabiting China, and "there is nothing in the impressions from Bonn to render it necessary to modify that opinion. At "the same time it must be confessed that this identification may be erroneous, and that better "specimens may prove it to be even a species of *Tetradenia* or *Camphora*.

"The Podocarpus was referred, with some doubt, to *P. macrophylla*; and if not actually that "species, or *P. coriaceus*, a West Indian species, may at least be considered as certainly belonging "to the genus.

"Of the Palm very imperfect fragments only remain. They consist of strap-shaped impressions, "truncated at each end, with some of the parallel veins slightly thicker than the others, at rather "unequal intervals, and also with traces of parallel ribs; the lateral veins diverge from the ribs at "an angle of about 40°, and are remarkably well preserved.

"Imperfect as are these data, they seem at first sight to lead to the conclusion that the climate of "Bonn was tropical at the time of this deposit, because the Cinnamon is characteristic of the Flora "of the Indian Archipelago; Podocarpus is found in the West Indies and at Sincapore, while the "Palm might reasonably be considered in its natural station in such situations.

"But it may also be supposed, from the same evidence, that the climate of Bonn approximated "to that of the northern provinces of China, and the valleys of Nipal; for *Cinnamomum dulce*, to "which the cinnamon-like leaf may have belonged, is, as has already been stated, Chinese; while "the genera Tetradenia and Camphora range as far to the north as the mountains of Nipal, and "even Japan: and Cinnamomum itself finds its most northern limit only in the upper mountains of "Nipal, near the river Cosa. *Podocarpus macrophylla* itself has certainly been found in Nipal, "and probably near Nagasaki; and although it is impracticable to determine positively from "such materials as we have here preserved, to what species of palm the impressions belonged, yet "there is nothing in them at variance with the leaves of the modern Chamærops, one species of "which, the *Chamærops Palmetto*, now inhabits the South of Italy and Barbary, and another the "valleys of Nipal.

"It may, therefore, be safely concluded that the climate of Bonn, at the period of the brown coal "deposit, ranged between that of the Indian Archipelago and Nipal*."

b. *Remains of Fishes.*

Professor Broun†, in a paper on the fossil remains of fish, found in the papierkohle of this district, states that he examined some hundred specimens, and that, with the exception of one, of which the remains were very indistinct, all belonged to one species. They are usually from two to three inches long, rarely exceed three quarters of an inch in depth, and the head forms a fourth

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* See Appendix VI. p. 474.

† *Ueber die fossilen Reste der Papierkohle vom Geistenger Busch im Siebengebirge*, in Leonhard's *Zeitschrift für Mineralogie*, 1828.

part of the entire length*. Nothing of the substance of the fish remains, but there is occasionally a dark coaly matter marking the contour of the body: there is even no appearance of the fragments of scales, nor of fins, ribs, vertebræ, or bones of the head, but the forms of all are impressed on the Papierkohle with remarkable exactness, and they are for the most part quite entire. He considers them to belong to the genus Cyprinus, but to be dissimilar from any known species, and he has named it *Cyprinus papyraceus.* These impressions have been examined since that time by M. Agassiz †, and are mentioned in one of the memoirs he published, preparatory to his more extensive work on fossil fishes. He confirms the opinion of Professor Bronn, naming the species, however *Leuciscus papyraceus*, in conformity with a new division of the genus Cyprinus‡. Professor Bronn describes also a small crab, and Professor Goldfuss, in a recent memoir§, says that besides this specimen of the remains of Crustacea, there are three remarkable animals belonging to the Branchiopoda, the largest of which is more than an inch in diameter.

c. *Remains of Insects.*

These and the remains of some reptiles have been described by Professor Goldfuss in the memoir above quoted. Insects have been found in the papierkohle of Stösschen at the foot of the Mendenberg, at Orsberg near Linz, and at Friesdorf near Bonn. Sometimes nothingr emains but the impression of the form of their bodies; at other times the bodies form a thin, compressed, coaly scale, shining, and sometimes having a metallic lustre. They seem to belong to the genera Lucanus, Meloe, Dytiscus, Buprestis, Cantharis, Cerambyx, Parandra, Belostoma, Cercopis, Locusta, Anthrax, and Tabanus.

d. *Remains of Reptiles.*

Professor Goldfuss describes a species of Frog, Salamander, Triton, and Ophis. These were found at Orsberg in the papierkohle. In this case, as in that of the fishes, the organized matter has almost wholly disappeared: very perfect impressions, however, remain, not only of the skeleton, but a dark shade in the coal marks the entire form of the animal, as in those anatomical plates where the skeleton is contained in a shaded form of the entire body. After a very careful examination, which he minutely describes, Professor Goldfuss satisfied himself that these remains belong to an extinct species of frog, which he has called *Rana Diluviana.* The salamander, which is about two inches long, also exhibits a structure somewhat distinct from existing species, and he has named it *S. Ogygia.* So with regard to the impression of a triton, about two inches long, and which he has named *T. Noachicus.* The remaining reptile he describes as being of a singular nature, the specimen exhibiting the appearance of two portions of a coiled snake,

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* Lord Cole informs me that he and Sir Philip Egerton obtained specimens from this place, of impressions of a fish of much larger dimensions, and I have seen that which is in the possession of Sir Philip Egerton. It is an impression of the skeleton of the tail end, and is probably not more than a half of the fish: it measures seven inches in length, and rather more than two inches in the broadest part.

† *Untersuchungen über die fossilen Süsswasser Fische der tertiären Formationen,* in Leonhard and Bronn's *Jahrbuch für Mineralogie,* 1832.

‡ See Appendix VII. p. 474.

§ *Beiträge zur Kenntniss verschiedener Reptilien der Vorwelt* in the Transactions of the *Kaiserliche Leopoldinisch-Carolinische Akademie der Naturforscher,* vol. xv.

one of which is the end of the tail: there are no traces of bones, but there are impressions of scales arranged in a diverging form downwards, on each side of a ridge: he calls it *Ophis dubius**.

e. *Remains of Quadrupeds.*

Professor Nöggerath, in describing the eighteen different beds composing the brown-coal formation at Putzberg near Friesdorf†, speaking of the ninth bed from the surface, says that there was once found in it a large tusk of a wild boar; and of the eleventh bed, that there was found in it the bone of the leg of an ox in a very complete state of preservation, together with some other fragments of bones. An occurrence so important in the history of this formation led me to call the attention of Professor Nöggerath to these passages in his memoir; when he informed me that in drawing it up several years ago he had inserted several things on the authority of others: that he has a distinct recollection of having seen the bones in the collection of a private individual in Bonn, which has since been dispersed, but that he did not see them himself *in situ*. Faujas St. Fond, in the memoir above quoted, says that a very old miner at Lieblar had told him that he had fifteen years before that time found a stag's horn in the brown coal beds.

Such is the whole result of my inquiry as to the existence of the remains of quadrupeds in the brown-coal formation; and unsupported as the facts are by any subsequent discoveries, very little reliance can be placed upon their accuracy.

The sandstone clay and lignite deposits above described constitute what may properly be termed the brown-coal formation of this district, but there is a small local deposit which I have yet to notice, and which, if it belongs to the same formation, is highly important as regards the question of age. In a valley behind Godesberg lies the old monastery of Marienforst, and going from thence to the village of Muffendorf, the path crosses the summit of the plateau; and here, about half way between the two places, there are strewed upon the surface of the ground small blocks of a white siliceous stone, containing casts of freshwater shells, with jointed stalks of a plant. Mr. Brassard, late keeper of the University Museum at Popplesdorf near Bonn, conceived that he had found the rock *in situ* at the same spot where the loose blocks occur, and I accompanied Professor Nöggerath and him to ascertain whether he was right in his conjecture, by digging round the mass. Although the ground was cleared away for some distance, and there was an excavation made in the rock to the depth of two feet, it is possible that it may still be only a large block. The stone is of a dull white colour, sometimes smoke gray like flint, generally of an earthy, but often of a crystalline translucent texture: in some places it

* Dr. Hibbert, in his *History of the Extinct Volcanos in the Basin of Neuwied*, has given a short account of the brown-coal formation of the Lower Rhine, which he says is drawn up from the writings of the German geologists. He appears not to have seen the memoir of Professor Goldfuss above mentioned, for he says, p. 86, that the brown-coal contains the remains of frogs and lizards "*still living*".

† In Von Moll's *Jahrbuch*, *uti suprà*.

contains yellow, brown, semi-opal, not to be distinguished from that which I have described as occurring in the quartzose conglomerate at Tänzchen, and like it passing into the mammillary structure of chalcedony. It contains numerous casts of Planorbes, Lymnei, and Paludinæ, and jointed stalks of a plant. I have examined above a hundred fragments, to try to discover Gyrogonites, but have found none. Mr. Lyell informs me that M. Deshayes, to whom he showed some of these specimens, found in them the three freshwater shells above named: he said that they do not look like modern tertiary shells, that the Planorbis appears, as far as can be determined by a cast, identical with *P. rotundatus*; that the Lymneus seems to be *longiscatus*, both occurring in the Paris basin. The plant is described by Professor Lindley to be fragments of dicotyledonous wood; and, in one of the specimens, there is a fragment of some organic body, which may have been the fruit of the palm, of which the nucleus is left entire, and the fleshy integuments half broken away.

This Marienforst siliceous rock has not been noticed by any previous writer on this district, probably because it has not been long known, as nothing of the kind exists in any other part of the district. If it had been at one time an extensive deposit, subsequently broken up, one could hardly fail to find fragments of it in the vast mass of gravel which covers the plateau; but this is not the case. On the other hand, I know of no rock in the adjoining country from which these blocks could have been derived; and had they come from a distance, it is not probable that they would have been confined to so small a spot. Although I do not mean to adduce it as a proof of identity, I would point out the almost identical semi-opal found in this rock and in the quartz conglomerate at Tänzchen. Upon the whole I am inclined to consider this as a small local deposit belonging to the same period as the brown-coal formation, and very possibly produced by some hot spring in the volcanic region holding silica in solution.

The brown-coal formation is covered by a mass of gravel almost throughout its whole extent, there being very few places where it is wanting. It is of very variable thickness, sometimes being only a thin covering, at others as much as eighty feet deep; and M. Von Dechen, in the memoir already quoted, describes a mass of sand which he considers as belonging to the gravel in the neighbourhood of Ichendorf, near Bergheim, of 125 feet in thickness. The gravel consists of rounded fragments of grauwacke and quartz, the latter greatly predominating, the pebbles generally small, about the size of a walnut; but very often large blocks, both of grauwacke, quartz, and basalt are imbedded in it. The pebbles are united by an argillaceous

sand containing much iron, so that the general colour of the gravel is yellow, very like that round London. I have never found any other fragments than those above named in the places where I have examined the gravel, but Professor Nöggerath informs me that he has found in it trachyte, transition limestone, and bunter sandstein. To trace the history of this vast accumulation of gravel would be an interesting inquiry; but it would require a very extensive series of observations, a minute acquaintance with the rocks of the Upper Rhine and the adjoining lands, and an accurate knowledge of the forms and levels of the country, before any satisfactory conclusions could be attained.

The gravel often lies immediately upon the lignite deposit, but frequently a bed of clay is interposed. The following section is constructed from the description given by Professor Nöggerath of the beds at Putzberg.

	Ft.	In.
1. Loam and marl (loess) of an average depth of	2	0
2. Gravel	13	0
3. Sandy loam	0	6
4. Earthy lignite and bituminized wood, lower part mixed with clay	3	0
5. Gray bituminous clay, bituminized wood, and clay iron stone...	4	6
6. Earthy lignite and bituminized wood	0	6
7. Bituminous brown clay.....	1	0
8. Earthy lignite and bituminized wood	0	6
9. Gray plastic clay	5	0
10. Earthy lignite and bituminized wood.....	8	0
11. Highly bituminous and pyritous clay	5	0
12. Leafy mass; chiefly bituminized stems, branches and leaves ..	1	6
13. Bituminized wood.....	1	6
14. Same as No. 10.	3	0
15. Same as No. 12.	2	6
16. Same as No. 10. and 14.	1	6
17. Same as No. 12. and 15.	2	6
18. Same as No. 9., bored into to the depth of.....	24	0
	79	6
Of which the lignite beds constitute	24	6

In most places the lignite rests upon clay, and below that come the sandstone and loose sand, the latter being generally the lowest. At Roisdorf, near Bonn, the sandstone is covered by bituminous clay; and at Frechem, near Brühl, thick beds of clay and lignite lie upon loose sand. In many places the sandstone occupies the surface, so that the clay and lignite have either never been deposited upon it, or have been carried away by sub-

sequent denudation. At Friesdorf the clay and lignite beds rest immediately upon the ends of highly inclined strata of grauwacke. I have already noticed, p. 442. the alternation of trachyte tuff with the beds of the brown-coal formation; and at p. 441. I have described the occurrence at Quegstein of trachyte tuff lying upon sandstone. I have also said, p. 443. that basalt occurs in connexion with the brown-coal formation: the place where this has been most distinctly seen is at Utweiler, on the north-eastern border of the district, about four miles from the centre of the trachytic and basaltic eruptions of the Siebengebirge, but situated in a valley between two knolls of basalt, the Rother Hardt, nearest to it, and the Hinzberg, not very far off. I visited this place in 1832 with Professors Nöggerath and Mitscherlich, to see the workings in a new shaft which had been sunk to obtain the coal. The former has lately published in Karsten's *Archiv für Bergbau*, &c., an account of his observations, together with some subsequently made by M. Augustus von Strombeck, on this occurrence of basalt in the lower ground. M. von Strombeck drew up the following account of the different beds sunk through in the new shafts:

	Ft.	In.
1. Soil	2	6
2. Loess	9	5
3. Basalt	30	6
The upper part consists of globular masses in some degree decomposed; then comes a dark gray compact basalt, containing olivine, augite, and magnetic iron ore, but not regularly columnar.		
The lower part of the mass is formed of		
4. A compact bluish gray argillaceous stone, a decomposed basalt or tuff, similar to what usually accompanies volcanic masses	1	3
5. Here begin the brown-coal beds properly so called; an indurated clay of a black colour from a mixture of coal, which splits into prisms about three inches long, and from eight to ten lines in diameter, the interstices filled with crystallized dolomite; a structure probably occasioned by the heated mass of basalt covering it	1	0
6. Dark-coloured clay, containing much coaly matter and pyrites, but neither slaty nor columnar	0	6
It is remarkable that this bed should show no indication of that columnar structure which is so marked in the beds which lie immediately above and below it. A similar fact has been observed in the Meisner.		
Then come the lignite beds, consisting of		
7. Black pitch coal, separating into prisms of from an inch to an inch and a half in diameter, standing perpendicular to the face of the basalt bed, with the interstices lined with crystallized dolomite	1	2
This passes gradually into		
8. A small coal	4	0

	Ft.	In.
9. Unaltered brown coal or bituminized wood, preserving the woody texture	8	6
Total thickness of coal 13 feet 8 inches.		
In the lower part of this last bed occur kidney-shaped masses of compact clay iron stone.		
	58	10

Then comes a trachyte tuff, with portions of hard trachyte, into which they had sunk to the depth of two feet. It is here the usual underlier of the brown-coal beds, but it is also found lying between them, so that it is very possible if the shaft were sunk deeper, that this tuff would be gone through, and other brown-coal beds be found below it.

M. Von Dechen states* that in the district of Brühl the beds lie considerably above the Rhine valley, and this seems to be equally the case on the right bank. It is worked at several places on the right bank, but by far the most considerable mines are on the other side of the river, and in the district immediately around Brühl. The united thickness of the lignite beds in different situations in the plateau is very various, often too inconsiderable to be worth working. It has not been ascertained by actual trial whether they stretch quite across the plateau, the mines being situated on the east and west sides, but this is very probably the case. The following table will show the thickness of the brown-coal beds at different points on each side, lying east and west of each other. The thickness includes the clay beds that may be interposed between one layer of brown-coal and another.

West Side.	Feet.	*East Side.*	Feet.
		Walberberg near Brühl ....From	12 to 30
Lieblar.....From	6 to 66	Metzmacher.....	26 to 49
		An der Gabgay	43
		Pingsdorf.....	36½
Zisselsmaar	16 to 63	Hennersgrube	40 to 52
Turnich	10 to 60	Altstädter Berg	6 to 60
		Gleneler Berg	18 to 70
Schlenderhan	14 to 40	Frechemer Berg	19 to 55

The various mines of brown-coal in the district give occupation to about 1200 persons. The coal is consumed almost entirely by the poorer classes, as its strong peculiar odour, and sometimes sulphurous vapours, render its use disagreeable. Some of the harder kinds are used as they are taken from the pit; but these form a small proportion, and are, moreover, not so valuable for fuel: the greatest part is used after it has been artificially prepared. It is

* Karsten's *Archiv, uti suprà*, p. 417.

beat and trodden after being well mixed with water, and is formed in shapes like the crown of a small hat, which are laid out to dry like bricks, and these when dry are preserved for use by being piled up under cover. In this state they are called *Klütten*, and are sold on the ground for about nine groschen per hundred; and as each of the klütten weigh about five pounds when dry, the price is equal to about four shillings per ton *.

The beds of the brown-coal formation are generally either horizontal or deviate only a few degrees from it. In the immediate neighbourhood of Utweiler, however, under a bed of loess about fourteen feet thick, there is a series of about twenty distinct strata of clay, distinguished by various colours, and containing four layers of lignite, each about six inches thick, which have an inclination about 60° S. This elevation was probably occasioned by the eruption of basalt which is in the immediate neighbourhood. On the left bank of the Rhine, and near Brühl, near which no unstratified rocks appear, there have been also considerable disturbances subsequent to the deposition of the beds. At Hennersgrube, near the old monastery of Beuten, the lignite beds are suddenly cut off by a fault to the depth of forty-nine feet†.

By referring to the Map, it will be seen that the brown-coal formation exists to a considerable extent within the volcanic region of the Siebengebirge, especially in the valley of Haisterbach. It is found in two small patches in Königswinter valley, one at a place called Kuckstein, pretty high up in the ascent to the Drachenfels, where clay beds are found; the other in the bottom of the valley at Quegstein and Tänzchen, as already mentioned. Here the sandstone members of the series only occur, the quartzose conglomerate occurring in great detached masses, seemingly piled together. These probably formed indurated portions in a deposit of sand, which has been since washed away, as has been often noticed in sandy beds of the plastic clay and other tertiary deposits.

In the southern parts of this district the brown-coal formation occupies much higher situations. The Papierkohle of Orsberg, near Erpel, which contains the impressions of reptiles and insects, is 372 feet above the Rhine; and continuing the ascent towards Bruckhausen, there is a plateau of about a mile square, which seems to be entirely composed of the brown coal formation. At the very foot of the Mendenberg, at Ehl and at Stösschen, there is a very extensive deposit of lignite on the slope of the mountain, very high above the adjoining valleys, which has long been worked for the purpose of making alum, the clay and lignite being highly pyritous. The latter splits into thin plates, and contains numerous impressions of leaves, and occasionally those of insects, and is about sixteen feet thick. The beds occur close to the basalt; and the workmen told me that they rise towards it, but that the actual contact is not seen. It appears that formerly four different beds

* The pigment called Cologne earth is prepared from an earthy lignite. It is said that a great quantity of the light pulverulent varieties is sent to France and Holland, to be used in the adulteration of snuff.

† Von Dechen, in *Karsten, uti suprà.*

of lignite were worked, separated from each other by clay and friable sandstone *. The Mendenberg is 1198 feet above the Rhine, and the lignite beds occur within 300 feet of the summit.

Loess.

The substance to which this name is applied is a sandy calcareous loam of a yellowish brown colour, slightly coherent, and absorbing water with great avidity. It is a deposit which has been generally considered to be peculiar to the Rhine valley †, and it is found, to a great extent, at detached points on both sides of the river, from Basle to Bonn. It has not been noticed by previous writers on the district described in this paper with that attention to which its geological importance entitles it. Loess is specially noticed by Leonhard in his *Charakteristik der Felsarten*, published in 1824, who has adopted this trivial name, given to it in the neighbourhood of Basle ‡; but a fuller account of it has more recently been given by Professor Bronn §, in his description of the environs of Heidelberg, and from which I have put together the following particulars.

It is found on the sides of the hills next the Rhine valley, and penetrating into the side valleys, such as that of the Neckar, Mayn and Lahn, and occurs chiefly in those situations where the form of the land presented a barrier against its being washed away by a descending stream. It is, for example, more abundant near Worms and Oppenheim than near Heidelberg, because the force of the Rhine is chiefly directed there against its right bank. It is found at various distances from the plain of the Rhine, as much as nine miles, and it is in some places 600 feet above the level of the sea.

One hundred parts of that near Heidelberg yielded 50 per cent. of siliceous sand, $16\frac{1}{2}$ of

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* Von Oeynhausen and Von Dechen in *Hertha*, vol. xii. 1828.

† In the synopsis of the successive deposits in the basin of Vienna, given by Mr. Murchison, the uppermost is described to be "Alluvial loam, called *Löss*, with terrestrial shells of existing "species, (of the genera Pupa, Helix, and Succinea,) mixed with bones of elephants of extinct spe- "cies. The average thickness of this deposit is about 60 feet, but at some places the thickness is "much greater." Further, "It is greatly expanded near Krems and St. Polten, reaching occasion- "ally the thickness of 140 feet, and having, near these places, the exact appearance of the old allu- "vial hillocks in the valley of the Rhine, which have been described by M. Voltz."—*Geological Transactions*, vol. iii. pp. 402, 405.

Loess is said to occur also in the valleys of the Garonne and the Allier.—Rozet, *Journal de Géologie*, i. 57.

‡ It is mentioned by the name of *Britz* by Steininger in his *Neue Beiträge zur Geschichte der Rheinischen Vulkane*. 1821. 8vo.

§ *Gæa Heidelbergensis, oder Mineralogische Beschreibung der Gegend von Heidelberg*. 1830. See also Voltz, *Uebersicht der Mineralogie der beiden Rhein-Departemente*; and Rozet, *Sur le Diluvium de la Vallée du Rhin*, in *Journal de Geologie*, vol. i.

argillaceous earth, nearly 32 of carbonate of lime, a trace of magnesia, and it was coloured by iron and manganese.

In the immediate vicinity of the primary mountains it has a somewhat different character, being more sandy, and containing mica.

The loess does not contain what can properly be called petrifactions, but a vast number of calcined land-shells of living species, more usually in the upper than in the lower parts of the deposit, and they seem to belong to particular horizontal beds. There have been found near Heidelberg the following species: *Helix pomatia, H. nemoralis, H. hortensis, H. hispida, H. ericetorum, Bulimus radiatus, B. lubricus, Lymneus ovatus.* Some years ago, the lower part of an elephant's tusk was found near Weinheim, at an elevation of 100 feet above the Rhine, and some fragments of elephants' grinders had been previously found at a little distance from the same spot.

It is found lying on granite, porphyry, red sandstone, muschelkalk, keuper, and lias, and near Oppenheim on grobkalk (calcaire grossier).

The greatest elevation at which I have seen loess in the district described in this paper is near Erpel, above Orsberg, where it lies upon the brown-coal formation, a height which is fully 400 feet above the Rhine*; and it occurs, at about 200 feet high, near Steinsbusch, above Honnef.

A very extensive deposit of it may be seen at the Bruckersberg, near Rhöndorf, immediately south of the Drachenfels, where it forms an irregular mass from three to twenty-five feet thick, and covers trachyte and grauwacke, as represented in the wood-cut, p. 440. It is found at Quegstein in the valley of Königswinter, covering trachyte tuff, and near Paffroth and Ober Dollendorf, on the slope of the Petersberg, covering grauwacke. Between Ober Dollendorf and Haisterbach it lies upon grauwacke, covering the summit of a ridge over which the road passes, in the side of the valley leading to the Stenzelberg, and at Roth Kreuz, covering trachyte tuff. It is found in the narrow valley which opens at Ober Cassel, and covering basalt at a considerable elevation on the Rabenlei. It occurs also, to the depth of fourteen feet, near Utweiler, covering basalt. These are the places where I have seen it on the right bank of the Rhine; but it is met with, no doubt, in many others. On the left bank a narrow ridge of it runs in a south-east direction from Bonn for about three miles; and it is seen in the high bank of the river, covering the gravel of the Rhine plain, the surface of which is deeply channelled, the loess filling up the furrows. It is seen on the north-western slope of the Kreuzberg, in the valley between the Kreuzberg and Venusberg; in a valley behind Godesberg, near Marienforst; to a considerable extent near Lannesdorf, where very deep clefts are cut in it; and it skirts the northern and eastern sides of the volcano of the Roderberg. Above Rolandseck there is a quarry of grauwacke, and upon the ends of the elevated strata of that rock lies gravel covered by loess. The basaltic columns in the quarry opposite to Unkel are covered by it at a very great height above the river, and where it is nearest to the basalt it contains rounded fragments of that rock. It is here, as elsewhere, an unstratified mass, which seems to have filled up deep furrows and irregularities of the preexisting surface. The absence of all signs of stratification is universal in this district. At Unkel it contains a considerable quantity of calcareous concretions.

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* Dr. Hibbert says that at Monrepos, in the neighbourhood of Neuwied, about ten miles south of this spot, and on the same side of the river, loess occurs at a height of 600 feet above the Rhine; —History of Extinct Volcanos, &c., p. 205.

The following are the shells which I have found in it in this district: they were named by Professor Goldfuss. *Helix pomatia, H. nemoralis* Linn., *H. arbustorum* Linn., *H. hispida* Linn., *H. pulchella* Drap., *H. incarnata* Drap., *H. glabella* Pfeiff., *Lymneus minutus* Drap., *Pupa muscorum* Linn., *P. unidentata* Pfeiff., *Bulimus radiatus* Drap., *Clausilia obtusa* Pfeiff.

Bones of *Elephas primigenius* and *Rhinoceros tichorhinus* have been found in the loess which covers the basalt in the Unkel quarry. In that near Lannesdorf I found a fragment of a rib belonging to an animal of the size of a horse or ox, and I obtained from the neighbourhood of Ober Dollendorf a few bones, which upon showing to my friend Dr. Müller, Professor of Anatomy at Berlin, he considered to belong to the lower jaw of a young individual of a species of deer.

It is remarkable that such a deposit should be almost devoid of all vegetable remains. They are not noticed by Professor Bronn and other writers, and I have never found any*.

Valley of the Rhine.

The Rhine, from Linz downwards, flows through a deep deposit of gravel, with the exception of about three miles on the left bank, between Remagen and Rolandseck, where the hills come nearly to the water's edge, and the grauwacke strata appear in the side and channel of the river. The gravel is composed for the most part of grauwacke and quartz, but the former predominates. It is very distinct in its character from that which covers the brown-coal beds on both sides of the river, in which quartz is the prevailing material, and which is usually of a bright yellow colour, from an admixture of oxide of iron, which I have never found to be the case in the gravel of the plain, deep sections of which are shown in pits in several places distant from the river. It is of an unknown depth; wells which have been sunk sixty feet have not passed through it†.

The plain which spreads out on both sides from the gorge near Rolandseck, has by no means an uniform flat surface: there are long low ridges in the direction of the stream, but not parallel to its present bed, which seem to indicate that the Rhine, previous to the historical epoch, had occupied a different channel from that in which it now flows: that at one time its course was very near the foot of the ridge from Ober Cassel to Küdinghoven, and at another time close under the brown-coal plateau on the left bank, westward of Bonn. The situation of Cologne, founded in the early part of the first century, proves that it has flowed in its present course for at least eighteen hundred years.

* See Appendix VIII. p. 474.

† See Appendix IX. p. 478.

Mineral Waters.

There are three springs of some celebrity ; at Roisdorf and Godesberg near Bonn, and at Heppingen near Landskron, in the valley of the Ahr. They are cold, and contain a considerable quantity of carbonic acid gas. Their contents, according to analyses which have been published, are as follow :

Roisdorf*, 1·37 volume of carbonic acid gas :

Carbonate of soda	7·86
Sulphate of soda	4·78
Muriate of soda	19·01
Phosphate of soda	0·06
Carbonate of lime	2·81
Carbonate of magnesia	3·98
Iron, alumina, and silica, about	·27
	38·77 in 10,000 parts.

Godesberg †, about 16 cubic inches of carbonic acid gas in a pound of the water, and

Carbonate of soda	7·00 grains.
Carbonate of magnesia	3·32
Carbonate of lime	2·70
Muriate of soda	1·33
Carbonate of iron	·75
	15·10 in 1 lb.

Heppingen ‡, 80 cubic inches of carbonic acid gas in 100 cubic inches of water, and one pound of water yielded

Carbonate of soda	6·20
Carbonate of magnesia	2·40
Muriate of soda	3·00
Sulphate of soda	2·10
Carbonate of lime	1·30
	15·00

No mineral waters appear to have been found within the region of the Siebengebirge § ; and no water from which any calcareous deposit has been produced exists in any part of the district : there seems, indeed, to be an entire absence of limestone in any form.

* Bischof, *Die Mineralquellen zu Roisdorf.* Bonn, 1826.

† Wurzer, in Harless, *Gesundbrunnen in Grosherzogthum Nieder Rhein.* 1826.

‡ Funke, in Harless, *uti suprà.*

§ Harless, *uti suprà.*

Of the relative Ages of the Sedimentary Rocks.

The oldest of these is the grauwacke, and, as I have already said, it has every appearance, in the more northern part of the district at least, of belonging to the latest periods of that formation. The whole series of the secondary rocks, from the grauwacke to the chalk, inclusive, is wanting; not a trace of them is to be found *in situ* in any part of the district *.

This brown-coal formation has been hitherto held by those who believe in the universality of tertiary formations, according to the types in the Paris basin, as belonging to the plastic clay; but on what grounds I have not seen stated. The clays, sands, sandstones, clay ironstone, pyrites †, gypsum, and the lignite itself, when without a recognisable organic structure, prove nothing as to age, for all these are found in formations much earlier and much later than the plastic clay. We can found no safe reasoning upon any other ground than upon a comparison of the organic remains with those in other deposits.

The Flora of the several brown-coal or lignite deposits has not yet been explored by a botanist of authority, with the exception of the short notices we have received from M. Adolphe Brongniart. It is to be hoped that in the future progress of his valuable general work he will direct his special attention to this branch of his subject. In his *Prodrome d'une Histoire des Végétaux Fossiles*, published in 1828, he says, "From all I have yet seen I do not be- "lieve that a single distinctly dicotyledonous *leaf* has ever been found in any "formation older than the chalk. Future researches may prove the existence "of such vegetable productions in the secondary periods, but it is at least cer- "tain that they are extremely rare, and that they did not begin to be very nu- "merous until the period which succeeded the deposition of the chalk." (p. 148.) In speaking of the lignite formation, including those of the molasse and plastic clay, he says, "This formation is one of the richest in vegetable remains, but "it is however very rare to find them in such a state of preservation that they "can be determined with any degree of precision; or they belong to classes of

* M. Alex. Brongniart has been much misinformed when he says, "Les masses immenses de "lignite terreux de Bruhl et de Liblar, ne peuvent être placées que *sur la craie tufau, qui est la roche "fondamentale de ce pays.*"—*Descr. Min. des Environs de Paris*, 345; and *Dict. des Sciences Natu- "relles*, art. Lignite, p. 386.

† M. Alex. Brongniart says, "*Les terrains thalassiques ne contiennent même au dessus des ar- "giles plastiques aucun sulfure métallique en quantité notable.*"—*Tableau des Terrains*, p. 129. Were there no exceptions to this rule, the existence of pyrites would become a valuable document for the determination of the ages of deposits; but the London clay abounds in pyrites.

"plants in which the power of determination becomes much more difficult." (p. 205.) He only alludes to the brown-coal of this district, by naming among the Palms "*Cocos Faujasii,*" and under Monocotyledons of uncertain families "Endogenites"; both from Liblar. M. Alex. Brongniart, who has entered more fully into the subject of lignite than any other systematic writer I have met with, both in a special article on lignite in the *Dictionnaire des Sciences Naturelles,* and in his *Tableau des Terrains,* assigns this deposit to the plastic clay; but it is obvious that he has not visited the spot himself, and that what he says about it, as well as the above notice of it by his son, is taken in great part from the memoir of Faujas St. Fond, above quoted, who thirty years ago visited the Liblar mine only, and in whose memoir everything that relates to organic remains is far from satisfactory, in so far as regards observations on the spot by the author himself.

Now although the leaves of dicotyledonous trees may settle the question of this lignite deposit being superior to the chalk, they do not fix it to any particular epoch of the tertiary period, unless it can be shown that they have an equally limited range; and it has not yet been ascertained what species of dicotyledonous leaves are peculiar to the earlier, what to the later beds of the tertiary series, and whether there be any common to all. So far, therefore, the present state of our knowledge of the fossil botany of the deposits above the chalk does not afford any sure criterion for determining the age of a bed.

The usual and most exact medium of identification, by the remains of molluscous animals, entirely fails in this case; for, with the exception of the siliceous mass or blocks at Marienforst, not a single shell of any description has been found in any part of this brown-coal formation*. Now these are abundant in the lignite deposits of the Paris basin, of Soissons, of those in the molasse of Switzerland, and in the great deposit in the valley of the Inn at Häring, which may be taken as types for comparison; and, moreover, in all of these, marine shells are more or less mixed with those of fresh water. So far, therefore, all proofs of similarity fail; nor do we derive any aid from superior beds, as these are entirely wanting in this district. We are thus limited to the evidence which can be derived from the remains of fish, insects, reptiles, and the Marienforst shells.

Although found in considerable abundance, one species of fish only has been met with in this brown-coal formation, the *Leuciscus papyraceus* of Agassiz, and that belongs to fresh water. Now in none of the great lignite deposits above mentioned have the remains of fish of any kind been yet

* See Appendix V. p. 473.

stated to have occurred; but Mr. Agassiz mentions that several species of the genus Leuciscus are found in the beds of Œningen.

With regard to the remains of Frogs, they do not appear to have been known to exist in a fossil state previous to the memoir of Professor Goldfuss on those found in the papierkohle of this district; for Cuvier says, under the head *Des Ossemens de Batraciens*, "Je crois qu'il n'y a de certain que ceux "des carrières si problématique d'Œningen*;" and here he does not allude to Ranæ. Mr. Murchison, however, in his late memoir on Œningen, when speaking of the collection of fossils from that place in the museum at Carlsruhe, says, "I observed specimens of Rana and Testudo." I have had no means of ascertaining whether the same species of Salamander exists at Œningen with that found in our papierkohle; but Professor Goldfuss informs me that the *Salamander Ogygia* is scarcely to be distinguished from the living species.

The insects in the papierkohle are another distinctive character of this brown-coal formation, for no such occurrence has been mentioned in any of the other great lignite deposits above alluded to, and two of those found in the papierkohle also occur at Œningen, viz. Anthrax and Cerambyx.

It is impossible to decide whether the siliceous mass of Marienforst belongs to the lower or the upper part of the brown-coal formation, but the quartzose sandstones are always found in the lower part. As far as casts enable one to decide, and these only are met with, the species *Planorbis rotundatus* and *Lymneus longiscatus* have been made out by M. Deshayes. Mr. Lyell enumerates them in his Tables of shells, constructed on the authority of M. Deshayes, as occurring in his Eocene and Miocene periods, and not in the Pliocene.

It thus appears that there is no evidence to prove that this brown-coal formation belongs to the period of the plastic clay, and all the phænomena seem to assign it to a more recent period, and they prove it to be of purely lacustrine origin. It seems to have been deposited in a vast inland lake of fresh water, fed by some great river or rivers, which brought the sand and clay and wood, that subsided gradually to the bottom; and the perfect state of preservation of some delicate leaves shows also that the lake was surrounded by trees or shrubs.

I have been thus particular in endeavouring to fix the age of the brown-coal formation, not only on account of the great extent and importance of the deposit in itself, but because it affords, as I shall presently show, a criterion for judging of the period when the unstratified rocks of the Siebengebirge were ejected.

* Cuvier, *Ossemens Fossiles*, tom. v. p. 385.

Of the relative Ages of the Volcanic Rocks to each other and to the Sedimentary Rocks.

The trachyte tuff appears to me to be the oldest of the volcanic eruptions, for it has nothing of the character of having been derived from preexisting trachytes, and it is traversed by a dike of trachyte, as I have described at p. 439. This is quite in accordance with what takes place in active volcanos, where nothing is more common than for an eruption of ashes to precede that of a stream of lava; and it is also in accordance with what has taken place in another part of this district, at Siegburg, where dikes of basalt traverse basaltic tuff. The masses of solid trachyte contained in the tuff are not fragments, but, as was observed to me by Professor Mitscherlich while we were examining together the trachyte tuff of the Königswinter Hölle, are similar to the bombs we had found in such abundance in the ashes of the volcanos of the Eifel, and which are of frequent occurrence in the ashes of active volcanos*. They often, it is true, resemble, nay, are almost identical with, the trachyte of the adjoining hills, but they are very frequently of a kind unlike any found *en masse*. That there may be some secondary trachyte conglomerates is very probable; indeed I am inclined to consider that variety at Ober Cassel, containing portions of basalt and balls of clay ironstone, as having been derived from preexisting trachyte and trachyte tuff.

Previous writers on this district have said that they were unable to point out any difference of age between the trachyte and the basalt. I presume, therefore, that the dike of amygdaloidal basalt which traverses the trachyte in the Keilsbrunnen quarry must have been only lately exposed, for that is decisive of the question. Another proof of the basalt being more modern than the trachyte is, that the trachyte tuff, except in the case of that at Ober Cassel above alluded to, never, as far as my observations and information go, contains any detached masses of basalt. There is, besides, no instance of a trachyte dike traversing basalt, but many of the latter traversing trachyte tuff.

That the trachyte and basalt are later than the grauwacke requires scarcely

* Mr. Poulett Scrope in describing the trachyte tuff of the Ponza Isles (which he calls conglomerate,) mentions the occurrence of numerous "fragmentary blocks" in it, and says, "None of the fragments are water-worn, and they all have evidently been enveloped in the base immediately upon their ejection by the volcanic impetus." He also shows that eruptions of solid trachyte have taken place subsequently to the ejection of the tuff: "this rock [prismatic trachyte] bears on most points the appearance of having forced its way upwards by cutting through the incumbent conglomerate in various directions, and occasionally of having spread laterally over it."—*Geological Transactions*, Second Series, ii. 203 and 206.

to be mentioned; the numerous fragments of it included in the volcanic rocks, and the basalt rocks traversing it, remove all doubt. The great disturbance of the grauwacke strata in the neighbourhood of the trachyte and basalt may have been produced by their eruption.

It is clear that volcanic eruptions took place during the deposition of the beds of the brown-coal formation.

Trachyte tuff covers the sandstone at Quegstein, alternates with clay and clay ironstone in the neighbourhood of Rott and Utweiler, contains fragments of wood at the Langenberg, and leaves of trees, identical with those found in the papierkohle and sandstones, at Scheuern and Ofenkulenberg*. The basalt tuff of Siegburg contains fragments of wood, bituminized and penetrated by iron, not to be distinguished from that found in the lignite deposits. In conformity with what has been said of the more modern age of the basalt, we find it at Utweiler lying over the brown-coal beds to the depth of thirty feet; and no fragments of basalt occur in any of the beds of the brown-coal formation, as far as I have been able to ascertain. Besides the instance of alternate beds mentioned above, the trachyte tuff in many places shows an arrangement that could only have been produced by the materials being moved under the surface of water.

All these facts seem to me to prove that volcanic eruptions were going on in a freshwater lake, in the same manner as we have submarine eruptions at the present day, during the time that the brown-coal beds were in the course of being deposited. It is probable, however, that all the volcanic rocks we now see were not ejected at that period, but that subsequent eruptions took place which heaved up the Siebengebirge and the cones to the south, carrying up the brown-coal beds along with them, in some instances, as at Stösschen, to the height of nine hundred feet above the present surface of the Rhine; the same action, probably, heaving up the plateau on the left bank of the river, although with a less degree of force, as the basaltic outbursts on that side are comparatively on a limited scale. The great fault in the brown-coal beds, described p. 459, indicates a powerful and sudden disturbing force. It would appear, also, that the great mass of gravel which covers the brown-coal beds had been strewed over them previous to this elevation, for it is found on both sides of the Rhine at a great height, and never in the intermediate plain, the gravel of which, as far as my observations go, has quite a distinct character.

I have endeavoured to obtain some distinct evidence as to the relative age of the volcanic eruption of the Roderberg, described p. 447, the whole characters of which are very different from anything in the Siebengebirge. I

* See Appendix X. p. 478.

have not been able to find anything more precise than that the loess at its base contains portions of scoriaceous basalt, and that a mass of the same gravel which covers the brown-coal formation, occurring at the edge of the crater, lies under a dark volcanic tuff, or indurated mud. Dr. Hibbert states that in the road from Andernach to Frauenkirchen he saw a section where a bed of pumice, twenty-one feet thick, lies over a fine loess from forty-five to forty-eight feet thick, and a coarser loess eighteen feet thick: he mentions other places, which show that the volcanos in the Lower Eifel were in activity subsequently to the deposit of the loess, and it is probable that this was also the case of the Roderberg*.

Of the relative Age of the Loess.

This remarkable deposit, abounding in terrestrial and fluviatile shells of existing species, and containing in many places, some of which are more than two hundred feet above the Rhine, bones of extinct species of the elephant and rhinoceros, rests at Bonn, as it does at Strasburg, upon a deep mass of that same gravel through which the Rhine flows in the greater part of its course from Basle. It is the latest deposit found in this district prior to the commencement of the recent period.

It is difficult to conceive how it should have been produced, except by some vast flood, which, if no elevations or subsidences of the land have since taken place, must have been of the depth of at least six hundred feet, and several miles in breadth, and so densely charged with mud as to leave behind, at an elevation of two hundred feet, masses covering hundreds of acres, two hundred and fifty miles distant from the spot where its first traces are to be seen, similar masses occurring at intervals not far asunder during the whole of that course. That it was a sudden inundation, and that the loess was not gradually and tranquilly deposited from stagnant water is probable, from there being no signs of stratification, by its containing the remains of land and fluviatile shells, and of land animals only, and by the great rarity of vegetable remains in it. That plants and trees were not swept along by such a flood is extremely improbable; but they would obviously not sink in so dense a fluid, hurried along with such a velocity as that with which it must have moved. Had there been a gradual subsidence, not only would there have been stratification, but beds of lacustrine and fluviatile shells, and abundance of leaves and other vegetable remains. We must ascribe such a flood to the sudden bursting of the barrier of a vast lake, the volume of water rushing over a great extent of land, and

* See Appendix XI. p. 478.

becoming charged as it rolled along with the earthy contents it afterwards deposited in the lower part of its course. We know that in the upper part of the Rhine valley, between the lake of Constance and Basle, there must have existed at one time a vast freshwater lake, where the great deposits of limestone and marl at Œningen took place, forming a mass of horizontal beds, six hundred feet thick, counting from the present bed of the Rhine. That the discharge of the waters when these Œningen beds were laid bare was that which brought down the loess is, perhaps, even a conjecture too hazardous from one who has never been near the spot. To give a history of the loess in the valley of the Rhine, by a careful examination of its composition, organic remains, its form of deposition and levels, and to trace it, if possible, to its source, would be a most interesting subject of inquiry, and could not fail to prove a valuable contribution to geological science.

It was my intention to have compared this district with the great trachytic eruptions of Hungary and Central France, but I found that to do so to any useful purpose, I must have entered into details which would have extended this paper beyond all reasonable bounds*.

Table of Heights.

The following heights are extracted from a Table of barometrical measurements, by M. Moliere of Saarbruch, Civil Engineer, a manuscript belonging to the Council of Mines at Bonn.

The measurements are in Paris feet†, above the mean height of the surface of the Rhine at Bonn, which, according to Van der Wyck, is 193 English feet above the level of the sea. I have classed them according to the nature of the rock at each place.

* See Appendix XII. p. 479.

† 1 Paris foot = 1·0658 English; so that adding $\frac{1}{15}$th part of the height in Paris feet gives very nearly the exact height in English feet.

Grauwacke.

	Feet.
Greatest height to which it rises on south slope of Mendenberg	908
Ditto between the Hummerich and Mittelberg	841
Ditto on west slope of Petersberg	658

Trachyte.

Drenkelberg	1188
Brüngelsberg	1131
Lohrberg	1125
Scheerkopf	1073
Bruderkunzberg	1022
Hummerich	996
Gross Mittelberg	936
Buckeroth	927
Wasserfall	919
Perlen Hardt	917
Gross Rosenau	883
Gross Geisberg	871
Jungfer Hardt	865
Wolkenburg	865
Gross Breiberg	846
Schallenberg	818
Klein Mittelberg	799
Drachenfels	780
Stenzelberg	760
Hirschberg	579

Trachyte Tuff.

Rises to height of:	
On west slope of Oehlberg	933
At Margaretha Kreuz	834
On south-east slope of Geisberg	776
On north slope of Nonnen Stromberg	638

Basalt Dikes.

Keilsbrunnen, through trachyte	785
Löwenburg Tränke, through trachyte	949
Between Drachenfels and Hirschberg, through trachyte	443
Steinsbusch, through grauwacke	216
Siegburg, through trap tuff	211
Wolsberg, through trap tuff	230
Grimprich, through trap tuff	189
Königswinter Hölle, through trachyte tuff	184

Basalt.

Düsberg, near Linz	1325
Gross Oehlberg	1289
Löwenburg	1272
Mendenberg	1198
Klein Oehlberg	974
Leyberg	974
Petersberg	904
Nonnen Stromberg	818
Ober Dollendorf Hardt	619
Limberg	598
Gross Wirlberg	597
Steinringsberg	565
Hartenberg	550
Gross Scharfenberg	560
Thomasberg	541
Falkenberg	538
Rabenlei	420
Hinzberg	429
Finkenberg	210

Brown-Coal Formation.

Stöschen, at foot of Mendenberg	913
At village of Vinxel	400
At Orsberg, near Erpel	372
Between Drachenfels and Wolkenburg.	445
Auf dem Stein, near Ober Cassel, where a bed of silicified wood was found	402
At Rott, where fish are found	298
At Tänzchen, sandstone beds	226

APPENDIX.—March, 1836.

See Page 433.

I. Page 433.

M. van der Wyck makes the mean height of the surface of the Rhine at Bonn 188 Rheinland feet (193·6 English feet), and at Königswinter 192 Rheinland feet (197·72 English feet) above the level of the sea. *Barometer-Höhen—Messungen des Rheinstroms,* in Leonhard and Bronn's *Neues Jahrbuch für Mineralogie, &c.* 1835, p. 260. One Rheinland foot = 1·0298 English.

II. Page 434.

From the smallness of the scale to which my map has been reduced for publication, it is scarcely possible to define the boundaries of the several mineral formations with precision. Those who wish to examine the Siebengebirge will do well to provide themselves with a copy of a geological map published at Bonn in 1835 by Henry and Cohen.

III. Page 442.

M. Thomae, in the memoir cited in the next note, mentions the occurrence of trachyte tuff in the lane leading from Nieder Bachem to Liessem, p. 48.

IV. Page 447.

A very detailed account of the Roderberg has been recently published, entitled *Der Vulkanische Roderberg bei Bonn. Geognostische Beschreibung seines Kraters und seiner Umgebungen, von* Carl Thomae. Bonn, 1835. Those who wish to examine and understand the structure of this interesting geological feature of the district should take this memoir as a guide. I extract the following particulars in this place, and I have refered to it in other parts of this Appendix.

The highest point of the crater is 330 Rheinland feet (339·8 English feet) above the surface of the Rhine. He estimates the longest diameter of it at a thousand paces, and the shortest at seven hundred paces.

The lava at the north-east side of the crater was at one time quarried, in

the hope of obtaining millstones, like those of Nieder Mendig; but it decomposes readily when exposed to the air, and masses of sufficient size without rents could not be had.

Fragments of grauwacke and of quartz are common in the lava; they are fast imbedded in it, and their surfaces are frequently vitrified. These vitrified pebbles are met with abundantly among the scoriæ on the sides of the hill, varying in size from a foot to the tenth of an inch in diameter. "Any one," says M. Thomae, "who had not picked them up himself on the spot from "among the brown cinders, might swear they came out of a porcelain furnace." p. 17. Volcanic bombs are sometimes found, and some which M. Thomae "broke presented the following remarkable appearance. "Three almost per- "fectly round balls, the largest of which might be about the size of a man's "head, contained in the interior rapilli, small rounded portions of porous lava, "vitrified and non-vitrified quartz pebbles, and small fragments of grauwacke, "some friable, others vitrified, and some unchanged. The bodies, which were "of the size of nuts, filled the whole interior space of the bomb; they lay chiefly "loose, often five or six were adhering together, or single ones were fixed to "the sides of the bomb, so that in breaking the porous lava shell, which was "about a finger's breadth in thickness, great caution was necessary to prevent "the contents falling out. In the interior of one of the bombs there was a "small detached crystal of augite." p. 21.

V. Pages 450 and 465.

In Leonhard and Bronn's *Neues Jahrbuch für Mineralogie, &c.*, for 1835, p. 678, there is the following communication from Professor Nöggerath to the Editors.

"Bonn, 30 October, 1835.

"Hitherto no shells have been found in our Rhenish brown-coal. Recently "some freshwater shells were brought to me from a bed which seems to be in- "termediate between earthy brown-coal and bituminous (brown-coal) clay. "This bed, which is of inconsiderable thickness, covers the alternations of "compact clay ironstone, which occur near Rott, eastward of the Siebenge- "birge, an account of which is given in my *Rheinland Westphalen*, iv. p. 388. "You will see by the specimens sent herewith that the shells are changed into "a kind of brown-coal, and are almost quite flat. If M. Bronn will venture to "pronounce an opinion upon these, I should wish you to insert it along with "this notice in your journal."

M. Bronn adds, "All these shells belong to the genus *Planorbis*, but they "are so crushed as to be almost wholly unrecognisable. The largest and best-

"preserved specimen nevertheless appear to be *Planorbis carinatus*; the rest "seem to belong to the same species."

VI. Page 452.

I visited the lignite deposit at Friesdorf in September 1835, in company with Mr. Robert Brown, when he collected several specimens of the vegetable remains. He informs me that all the wood he found is coniferous, which, taken along with the evidence derived from the leaves already noticed, might point rather to a temperate than an equinoctial climate.

VII. Page 453.

M. Agassiz examined the specimens accompanying this paper, in a late visit to England. Besides the *Leuciscus Papyraceus*, he found another species, which he named *Leuciscus Macrurus*.

VIII. Page 462.

Since this paper was read, I have seen the loess in three situations, which are remarkable as connected with the geological events which, in comparatively recent times, have occurred in this district.

I learned in the summer of 1833, that, in the preceding spring, the proprietor of the farm in the bottom of the crater of the Roderberg, in sinking a well near his house, had passed through a bed of loess. I went there, accompanied by Mr. Lyell, and we ascertained that, after a few feet of scoriæ, they had found loess, and had penetrated it to the depth of 62 Rheinland feet (63·2 English feet), but without passing through it. Part of that which had been dug out was on the ground near the well, the rest had been scattered over the adjoining field. It had the usual characters, and several of the calcareous stony concretions were lying about.

In the left bank of the Rhine, a short distance below Neuwied, and near Andernach, I observed the loess lying under a bed of volcanic scoriæ, and that covered by a considerable thickness of alluvial soil.

On a visit to the Laacher See in September 1835, I observed a section close by the edge of the lake, and within a quarter of a mile of the monastery, where loess, containing its characteristic shells, is covered by a succession of beds of volcanic sand, scoriæ, and pumice, and altered fragments of grauwacke.

In a paper on the solid contents of the Water of the Rhine, which was read before the Geological Society in March 1834, and published in the London and Edinburgh Philosophical Journal for January 1835, p. 102, I showed that the

sediment obtained from a large quantity of the water has the same appearance, and is of the same composition as loess.

In the Edinburgh Philosophical Journal for July 1834, there is a paper by Mr. Lyell on this peculiar deposit: he has treated of it very fully in his "Principles of Geology," vol. iv. p. 44, 4th edition; he read some additional observations upon it at the Geological Society in December 1835, an account of which is given in the Society's "Proceedings," vol. ii. p. 221, and he again refers to it in his Address at the Anniversary of the Geological Society, in February, 1836. M. Thomae, in the work above cited, has recorded several interesting facts respecting the loess which lies around the Roderberg. We learn, from the observations of these gentlemen, the following particulars in addition to those mentioned in my paper.

Of the shells found in the loess near Bonn the terrestrial predominate greatly over the aquatic; the same rule holds good, though not to the same extent, with respect to the shells now drifted down by the Rhine, and contained in the mud and sand of its shores; and the greater proportion of these last agree specifically with those buried in the loess.—*Lyell, Memoir of* 1834, p. 3.

The loess absorbs water with great avidity, and where exposed to the action of water is often carried away in great masses. It affords a very fertile soil; but the husbandman is sometimes doomed to see his hopes blasted by a violent storm of rain washing away the whole soil from his field, laying the roots of his vines bare to the sun.—*Thomae*, 26.

On the east side of the Roderberg there are five round-back ridges, covered with vegetation, which seem to radiate from the lower part of the hill towards its base. These are composed of loess; and, at their inferior extremity, are in some places laid open, exhibiting a vertical section from twenty to thirty-five feet in height, resting upon a mass of gravel, identical in composition with that forming the present bed of the Rhine, and from four to eight feet in thickness.—*Thomae*, 29—31.

"On the north-north-west side of the Roderberg a valley separates the volcano from the Zilliger Haidchen, heathy hilly ground composed of loess, which is furrowed in several places to a great depth. These excavations are called in German *schluchten*, meaning hollow ways. In some of these the loess is seen to be intermixed with volcanic products, and containing detached accumulations of scoriæ in amorphous masses. In several places there are continuous beds of scoriæ lying upon and covered by loess. In one of the *schluchten* a section is exposed, exhibiting alternate layers of scoriæ and tuff, resting on the fundamental grauwacke, and covered by loess; in another a

volcanic breccia, composed of fine blackish grey sand, including small fragments of clay slate and grauwacke five feet thick, rests upon loess, and is covered by another deposit of loess fifteen feet thick, identical in composition with the lower deposit. The flat surfaces of the slate and grauwacke fragments, and numerous scales of mica, lie horizontal, producing a slaty structure, and indicating their having assumed that position under the surface of water. The *schlucht*, which opens towards the village of Lannesdorf, exhibits a similar intermixture of scoriæ in the loess, and it is about two miles and a half distant from the crater of the Roderberg.—*Thomae*, 36—43.

I shall now point out some of the more important observations of Mr. Lyell on the loess in the higher parts of the Rhine valley and the adjacent country, contained in the memoirs above mentioned, which throw light on the history of this remarkable deposit.

He observed it near Andernach, alternating with volcanic scoriæ, &c., and in one place "covered with beds of pumice, trassy pumiceous sand, and small dark volcanic cinders, forming upon the whole a mass from ten to fifteen feet in thickness,"—ejections from the neighbouring volcanos of the Lower Eifel. In an excursion through part of the duchy of Darmstadt by Mayence, Oppenheim, Alzey, Flonheim, Eppelsheim, and Worms, he found the loess spread almost everywhere over the country. On the opposite side of the Rhine, in the elevated table land above the Bergstrasse between Wiesloch and Bruchsal he observed the loess attaining a thickness of 200 feet. Near Strasburg large masses of it are seen at the foot of the Vosges mountains on the left of the great plain of the Rhine, and at the base of the mountains of the Black Forest on the other side. It occurs in considerable force at Basle, and still higher up the Rhine at Waldshut, and it is said to terminate between that place and Schaffhausen. In the hills called Bruder Holz, about two miles south of Basle, it rests upon nearly horizontal beds of molasse, and it has here an elevation of more than 1100 feet above the sea, which is more than 900 feet above that ridge of loess that stretches between Bonn and Rüngsdorf. In a section exposed at Bruder Holz, he found the usual terrestrial and aquatic recent shells, and along with them two vertebræ, which M. Agassiz says belong decidedly to a small species of the Squalidæ, or Shark family, perhaps to the genus Lamna. Mr. Lyell has been so good as to allow me to have figures taken of these organic remains, the first ichthyolites hitherto found in the loess and so remarkable in a freshwater deposit*.

* See Plate XXIX.

Ascending the valley of the Neckar, he found a section near the Manheim gate of Heidelberg, exhibiting alternating layers of loess and gravel, to the thickness of 12 feet. He saw it near Heilbronn at an elevation of 500 feet above the level of the sea, and was informed that it lies on the hills in that neighbourhood, 300 feet higher. Further up the Neckar, at Canstadt, near Stutgardt, it overlies a freshwater formation of tuff travertine and marl, and south-east of Stutgardt, between Göppingen and the little watering-place of Boll, he found it in a valley watered by a small tributary of the Neckar. From Göppingen his route lay eastward by Weisenstein and Heidenheim to Nördlingen, and between Weisenstein and Heidenheim he crossed elevated land, on the west side of which the waters flow to the Rhine, on the east to the Danube, and eastward of this ridge no more loess was to be seen.

Returning again to the tributaries of the Rhine, in proceeding westward from Bamberg in Bavaria, he found the loess at Dettelbach, a small town on the Mayn, eastward of Würtzburg; and not only in the valley, but on the neighbouring hills of muschelkalk, at a height of five or six hundred feet above the valley. It was here of a somewhat redder tint than in Würtemberg, and Mr. Lyell conjectures that the colouring-matter may have been derived from the neighbouring red bunter-sandstein. Lower down the Mayn, he again saw the loess at Höchst below Frankfurt, and at Soden, where it abuts against the elevated grauwacke ridge of the Taunus.

Crossing the Taunus to the valley of the Lahn, he again found the loess at the village of Elz near Limburg. "On the north of this village," he says, "is a hill, which forms one boundary of the valley of the Lahn, and here loess is seen with all its usual characters, with many land and freshwater shells, and alternating, as at Heidelberg, with gravel. I observed, in particular, a horizontal layer of white quartz pebbles, a foot and a half in thickness, resting on a mass of loess fifteen feet thick, and covered by loess five feet in thickness, the loess, in both situations, including in it entire shells. Following the road, I found the slope of the hill above to consist of horizontal beds of quartz pebbles, which have a base of loess. Hence it appears that the valley of the Lahn, which is excavated through highly inclined greywacke, has, at some period since its excavation, been partially filled up with beds of gravel alternating with loess, a great part of which has since been removed by denudation."

It is material to observe that all the above-mentioned places, where Mr. Lyell observed the loess, have a direct communication with the main valley of the Rhine; that is, form part of one hydrographical basin. The quantity left bears but a small proportion to the mass which we must suppose to

have been originally deposited. It has been shown that the great avidity with which it absorbs water, renders it liable to be easily washed away; and accordingly, wherever it is not protected by the form of the land, or by a dense covering of vegetation, it is carried off by every shower; and this is in a great degree the cause of the yellow colour and the muddy state of the Rhine after heavy rains.

IX. Page 462.

In a gravel-pit near Bonn, I found a tooth of the *Rhinoceros tichorinus*. The gravel is not that yellow alluvium which lies over the brown-coal formation, but resembles that of the present bed of the Rhine, and which I have shown to be older than the loess.

X. Page 468.

Trachyte tuff is intermixed with the upper beds of the brown-coal formation in the lane between Nieder Bachem and Liessem, on the left bank of the Rhine.—*Thomae*, p. 49.

XI. Page 469.

We have seen that from the volcanic focus of this district, limited though it be in extent, products have been erupted which differ very much in their nature, and that these different products must have been ejected at distinct periods. The trachyte tuff appears to have been the first eruption, then trachyte, then basalt, and lastly, the lava and scoriæ of the Roderberg, which resemble the ejections of the neighbouring Eifel, and partake very much of the characters of those of active volcanos whose productions have more of an augitic than a felspathic nature.

That there was an eruption from the Roderberg subsequently to the commencement of the deposit of the loesss, is proved by the thick beds of scoriæ which are incumbent upon loess near Lannesdorf; and that it had become extinct prior to the termination of that particular deposit is shown by beds of loess covering the volcanic ejections, and still more conclusively by its accumulation to so great a depth in the very bottom of the crater; for had the volcano been subsequently in activity, the loess must have been blown into the air. That the edge of the crater must, in part at least, have been under the surface of the water which transported the loess, is manifest, and that collected at the bottom is probably the amount of the solid contents of the fluid which filled the cavity. All the phænomena seem to lead to the conclusion, that the Roderberg was a subaqueous eruption during the period of

the loess, and that it was subsequently raised up gradually, *en masse*, into its present position.

XII. Page 470.

The additional facts which have come to my knowledge since this paper was read, the most important of which are narrated in the preceding notes, have led me to modify in some degree the opinions I had formed relative to the history of the loess.

Its origin remains as uncertain as before; but it is very evident that it came from above Schaffhausen; and as it is so uniform in its nature throughout, with the exception of the somewhat redder tint of that at Dettelbach on the Mayn, which may have been produced by some local intermixture, it is fair to presume that it was derived from one source.

Do its characters indicate that it was brought down by the water of the Rhine, and was deposited gradually during a long period; or, that it subsided in a vast lake, into which the Rhine then entered, as the Rhone now does into the lake of Geneva, and whose waters ran up into all those sinuosities of the land where remains of the deposit are still to be found? or, do they point to the sudden rush of a muddy torrent, occasioned by the bursting of a barrier which drained a vast lake, as I have already suggested?

The generally homogeneous unstratified nature of the loess, even though in masses between 200 and 300 feet in thickness, always appeared to me to be strongly presumptive evidence that it was deposited from a flood of water densely loaded with mud, and moving with a velocity sufficient to transport its solid contents to a distance so great as that from Basle to Bonn, before they had time to fall to the bottom; but the alternations of loess with gravel in the valleys of the Neckar and the Lahn, and with volcanic ejections around Andernach, the Laacher See, and the Roderberg, show that, if it was a flood, there must have been more than one.

Were the idea of a lake at all admissible, there would be nothing extravagant in supposing that the loess near Basle, which is more than 1100 feet above the level of the sea, and that of Bonn, which is less than 200 feet, might have been deposited in one and the same lake; for it is only supposing the water at the latter place to be 900 feet deep; and the lake of Geneva, according to Mr. De la Beche, is in some places 984*. But if the loess were a gradual deposit from the waters of a lake, there would surely have been indications of successive layers in the structure of the loess itself; the shells would have been found more frequently in something like a similar

* *Manual*, 3rd edit. p. 22.

mode of arrangement, in place of being scattered, as they generally are, without order through the mass; and vegetable remains would not have been entirely wanting; or so rare, if they do exist. Then there must have been a barrier to contain the waters of the lake, at the head of the delta of the Rhine near Bonn, and that barrier must have been wholly swept away; but a country with forms more unlike those which we might expect, had such a barrier ever existed, can hardly be imagined.

All the appearances of the Rhine valley favour the supposition that, at the time of the deposit of the loess, there was a free river communication between Basle and the sea, and the vertebræ of the Lamna certainly render that supposition more probable. "It may seem very extraordinary that the first remains of fossil fish obtained from this freshwater silt should belong to a marine genus, but M. Agassiz has informed Mr. Lyell that both in the Senegal and the Amazon certain species of the Shark and Skate families (Squalus and Raia, Linn.) have been known to ascend to the distance of several hundred miles from the ocean, and analogous facts are referred to in Margrave and Pisa's Natural History of India*."

In a work descriptive of Bonn and its neighbourhood†, there is the following statement. "The chronicle of Bonn further informs us of a visit to "our river from an animal of the remote north; a sea monster, whose appear-"ance may be brought forcibly before our imagination by the steam-boat of "modern days, as it works its way through the waters of the Rhine. In the be-"ginning of the year 1680, a Sea Cow, or Walrus, more than fourteen feet in "length, was seen swimming up the Rhine past Bonn. A violent and unheard-"of agitation of the water was observed, accompanied by a loud noise, and by "two lofty jets of water spouting from the forehead of the monster. The whole "town rushed to the river to see the great beast, the very name of which was "then unheard of by them. The centinel on the Alten Zoll fired at it several "times but missed it, and the animal proceeded on its way upwards undis-"turbed, and is said to have got above Strasburg. Two months afterwards, it "was cast ashore dead, near the village of Niel, about three miles below Co-"logne, with four wounds from bullets below the head; but it was not known "by whom or where it had been killed."

In the present imperfect state of our knowledge, there seems to be no explanation, upon the whole, so rational as that suggested by Mr. Lyell in the Address above alluded to, who says, "Instead of supposing one continuous

* Geological Society's "Proceedings," vol. ii. p. 222.

† Hundeshagen, *Die Stadt und Universität Bonn am Rhein, mit ihren Umgebungen.* Habicht, Bonn, 1832, p. 15.

"lake of sufficient extent and depth to allow of the simultaneous accumulation "of loess at all heights and throughout the whole area where it now occurs, I "conceive that subsequently to the period when the countries now drained by "the Rhine and its tributaries, acquired nearly their actual form and geogra- "phical features, they were again depressed gradually by a movement like that "now in progress on the west coast of Greenland. In proportion as the whole "district was lowered, the general fall of the waters between the Alps and the "ocean was lessened, and both the main and lateral valleys, becoming more "subject to river inundations, were partially filled up with fluviatile silt con- "taining land and freshwater shells. After this operation, when a thickness of "many hundred feet of loess had been thrown down slowly, and in the course of "many centuries, the whole region was once more upheaved gradually, but "perhaps not equally, throughout the whole region. During this upward move- "ment most of the fine loam was carried off by denudation to such an extent that "the original valleys were nearly re-excavated. The country was thus restored "to its pristine state, with the exception of those patches of loess still remaining, "and which, from their frequency and their remarkable homogeneousness of "composition and fossils, attest the original continuity and common origin of "the whole. By introducing such general fluctuations of relative level, we may "dispense with the necessity of erecting and afterwards removing a great "barrier more than 1200 feet high, sufficient to exclude the ocean from the "valley of the Rhine during the accumulation of the loess."

Sweden has afforded the most unequivocal proofs that upward and downward movements of the land may take place in countries where no ordinary volcanic action is to be seen; and that so gradually, as to be imperceptible to all who are not watching the phænomenon: and, as there are so many indications of volcanic action in early times, on both sides of the Rhine valley, it does not seem to me to be stretching theory beyond the limits of just philosophical reasoning, to suppose that such oscillations may have taken place in this district, during the gradual accumulation of the loess, and subsequently to its deposition.

END OF VOL. IV.

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April 3.	Considérations sur les Ossemens Fossiles la plûpart inconnus, trouvés et observés dans les Bassins de l'Auvergne, par M. Geoffroy St. Hilaire.	The Author.
8.	Report on the Geology, Mineralogy, Botany, and Zoology of Massachusetts; made and published by Order of the Government of that State, with a descriptive List of the Specimens of Rocks and Minerals collected for the Government, by Edward Hitchcock, 8vo. Amherst, 1833.	The Author.
14.	Thirteenth Report of the Council of the Leeds Philosophical and Literary Society, at the close of the Session 1832–1833.	The Leeds Philosophical and Literary Society.
	Bulletin de la Société Géologique de France, tome 4ème, feuilles 6–9, 8vo. Paris, 1833.	The Geological Society of France.
	Proceedings of the Royal Society of Literature, vol. 1, No. 5, January to March 1834.	The Royal Society of Literature.
	Proceedings of the Royal Society, No. 15, December 1833, to March 1834.	The Royal Society.
	Lettre sur le Déluge de la Samothrace à M. A. M. Létronne, par M. Théodore Virlet, 8vo.	The Author.
	Notes Géologiques sur les Isles du Nord de la Grèce, et en particulier, sur un Terrain de Calcaire d'Eau douce à Lignites, par M. Théodore Virlet. Extrait des Annales des Sciences Naturelles, tome 30ème, 8vo.	.....
	Asiatic Researches. Transactions of the Physical Class of the Asiatic Society of Bengal, part 2, 4to. Calcutta, 1833.	The Asiatic Society of Bengal.
16.	Proceedings of the Committee of Science and Correspondence of the Zoological Society, for May, June, July, August, September, October, November and December 1833, with a List of Contributors.	The Zoological Society.
	Prospectus of a Joint Stock Company for the Improvement of Ireland, 8vo. London, 1834.	Lt.-Col. Colebrooke, F.G.S.
	Gedrängte Uebersicht der Ergebnisse einer geognostischen Erforschung des Odenwaldes und einiger angrenzenden Gegenden, mit besonderer Rücksicht auf Andeutung der Verbreitungsgebiete der Formationen, von Dr. A. Klipstein, 4to. Heidelberg, 1829.	The Author.
	History of the Berwickshire Naturalists' Club, instituted Sept. 22nd, 1831, 8vo. Edinburgh, 1834.	The Berwickshire Naturalists' Club.
25.	The History of the Royal Society of London for the Improving of Natural Knowledge, by Thomas Sprat, 4to. London, 1667.	Roderick I. Murchison, Esq. V.P.G.S.
	Transactions of the Royal Society of Edinburgh, vol. 12, part 2, 4to. Edinburgh, 1834.	The Royal Society of Edinburgh.

1834.	BOOKS.	DONORS.
April 25.	Proceedings of the Royal Society of Edinburgh, Nos. 1 and 2, December 1832 to May 1833, and No. 3, December 1833 to January 1834.	The Royal Society of Edinburgh.
26.	Catalogue des Livres de la Bibliothèque de Feu M. T* * * * * *, 8vo. Paris, 1834.	M. Silvestre.
29.	M. A. Nattali's Catalogue of Books, for May 1834.	Mr. Nattali.
May 4.	The Transactions of the Linnean Society of London, vol. 17, part 1, 4to. London, 1834.	The Linnean Society.
	Mr. T. Rodd's Catalogue of Works on Arts and Sciences, and Natural History.	Mr. T. Rodd.
6.	Studi Geologici sulla Toscana del Professore Paolo Savi, 8vo. Pisa, 1833.	The Author.
7.	An Inaugural Lecture on the Study of Botany, read in the Library of the Botanic Garden, Oxford, May 1st, 1834, by Charles Daubeny, M.D. F.G.S. Professor of Chemistry and Botany in the University of Oxford, 8vo. Oxford, 1834.	The Author.
8.	Annual Report of the Council of the Yorkshire Philosophical Society, for 1833, presented to the Annual Meeting, February 4th, 1834, 8vo. York, 1834.	The Yorkshire Philosophical Society.
10.	Outline of the Geology of the Neighbourhood of Cheltenham, by Roderick Impey Murchison, Esq. V.P.G.S. &c. 8vo. Cheltenham, 1834.	The Author.
14.	Annual Report of the Committee of the Athenæum for the Year 1833, dated May 12th, 1834.	The Committee of the Athenæum.
16.	An Account of the Caves of Ballybunian, County of Kerry, with some Mineralogical Details, by William Ainsworth, Esq. 8vo. Dublin, 1834.	The Author.
19.	Memoirs of the Royal Astronomical Society, vol. 7, 4to. London, 1834.	The Royal Astronomical Society.
21.	Origines Biblicæ, or Researches in Primeval History, by Charles Tilstone Beke, Esq. vol. 1st, 8vo. London, 1834.	The Author.
23.	Note on a Paper by Dr. John Davy, entitled, "Notice on the Remains of the recent Volcano in the Mediterranean," by Charles Daubeny, M.D. F.G.S. From the Philosophical Transactions for 1833, 4to. London, 1833.	The Author.
	On the Quantity and Quality of the Gases disengaged from the Thermal Spring which supplies the King's Bath in the City of Bath, by Charles Daubeny, M.D. F.G.S. From the Philosophical Transactions for 1834, 4to. London, 1834.	.....
	Höhen Messungen inund um Thüringen, Gesammelt, Verglichen und mit einigen Bemerkungen begleitet, von K. E. A. von Hoff, 4to. Gotha, 1833.	The Author.
	Proceedings of the Royal Society, No. 16, April and May 1834.	The Royal Society.
June 3.	Bulletin de la Société Géologique de France, tome 4ème, feuilles 10–14, 8vo. Paris, 1833.	The Geological Society of France.

1834.	BOOKS.	DONORS.
June 3.	Table des Matières et des Auteurs pour le troisième Volume du Bulletin de la Société Geologique de France, par M. Clément-Mullet.	The Geological Society of France.
	Researches in Theoretical Geology, by Henry T. de la Beche, Esq. V.P.G.S. 12mo. London, 1834.	The Author.
4.	M. A. Nattali's Catalogue of Books, for June 1834.	Mr. Nattali.
	Magazin for Naturvidenskaberne. Udgives af den physiographiske Forening i Christiania, Anden Rœkkes, 1ste Binds, 2det Hefte, 8vo. Christiania, 1833.	H. C. Ström, Esq.
5.	Journal of the Royal Geographical Society of London, vol. 4, part 1, 1834.	The Royal Geographical Society.
7.	Transactions of the Cambridge Philosophical Society, vol. 5, part 2, 4to. Cambridge, 1834.	The Cambridge Philosophical Society.
18.	Experimental Researches in Electricity (Sixth and Seventh Series), by Michael Faraday, Esq. D.C.L. F.G.S. From the Philosophical Transactions for 1834, 4to. London, 1834.	The Author.
23.	The American Journal of Science and Arts, conducted by Benjamin Silliman, M.D. vol. 26, No. 1, 8vo. New Haven, 1834.	The Conductor.
25.	Descriptions of some new Species of Cuvier's Family of Brachiopoda, by W. J. Broderip, Esq. V.P.G.S. 4to. From the Transactions of the Zoological Society, vol. 1, part 2, 1834.	The Author.
	On the Anatomy of the Brachiopoda of Cuvier, and more especially of the Genera Terebratula and Orbicula, by Richard Owen, Esq. Assistant Conservator of the Museum of the Royal College of Surgeons in London, 4to. From the Transactions of the Zoological Society, vol. 1, part 2, 1834.	Wm. J. Broderip, Esq. V.P.G.S.
July 5.	An Address delivered at the third Annual Meeting of the Geological Society of Dublin, on the 13th of February 1834, by the Rev. Bartholomew Lloyd, D.D. President of the Society; to which is subjoined the Annual Report, &c. 8vo. Dublin, 1834.	The Geological Society of Dublin.
	Journal of the Geological Society of Dublin, vol. 1, part 2, 8vo. Dublin, 1834.	.....
8.	Premiums of the Society for the Encouragement of Arts, Manufactures, and Commerce, for the Sessions 1834–1835, 1835–1836, 8vo. London, 1834.	The Society of Arts.
	Annales des Mines, ou Recueil de Mémoires sur l'Exploitation des Mines, et sur les Sciences et les Arts qui s'y rapportent, rédigées par les Ingénieurs des Mines, et publiées sous l'Autorisation du Conseiller d'Etat, Directeur Général des Ponts et Chaussées et des Mines, 3ème Série, tome 6, 4ème livraison, 1834, 8vo. Paris, 1834.	L'Administration des Mines.
9.	The Athenæum Journal of English and foreign Literature, Science and Fine Arts, from January to June 1834, 4to. London, 1834.	The Editor.

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July 11.	Transactions of the Royal Asiatic Society of Great Britain and Ireland, vol. 3, part 3, 4to. London, 1834.	The Royal Asiatic Society of Great Britain & Ireland.
	The Journal of the Royal Asiatic Society of Great Britain and Ireland, No. 1, 8vo. London, 1834.	.....
13.	Notice of Fossil Bones found in the Tertiary Formation of the State of Louisiana, by Richard Harlan, M.D. Read October 19th 1832. From the Transactions of the American Philosophical Society held at Philadelphia, vol. 4.	The Author.
17.	Annales des Mines, ou Recueil de Mémoires sur l'Exploitation des Mines et sur les Sciences qui s'y rapportent, rédigées par les Ingénieurs des Mines, et publiées sous l'Autorisation du Conseiller d'Etat, Directeur Général des Ponts et Chaussées et des Mines, 3ème Série, tome 5ème, 11ème livraison de 1834, 8vo. Paris, 1834.	L'Administration des Mines.
19.	Report of the Third Meeting of the British Association for the Advancement of Science, held at Cambridge in 1833, 8vo. London, 1834.	The British Association.
22.	Philosophical Transactions of the Royal Society of London, for the Year 1834, part 1, 4to. London, 1834.	The Royal Society.
29.	A Manual of Mineralogy, comprehending the more recent Discoveries in the Mineral Kingdom, by Robert Allan, Esq. F.G.S. 8vo. Edinburgh, 1834.	The Author.
	Mémoire sur la Position Géologique des Principales Mines de Fer de la Partie Orientale des Pyrénées ; accompagné de Considérations sur l'Époque du Soulèvement du Canigou, et sur la Nature du Calcaire de Rancié, par M. Dufrénoy. Extrait des Annales des Mines, 3ème Série, tome 5ème, 8vo. Paris, 1834.	The Author.
	Transactions of the Zoological Society of London, vol. 1, part 2, 4to. London, 1834.	The Zoological Society.
Aug. 1.	Quelques Observations de Physique Terrestre, par MM. Auguste de la Rive et F. Marcet, 4to.	The Authors.
4.	Bulletin de la Société Géologique de France, tome 4ème, feuilles 15–19, 8vo. Paris, 1834.	The Geological Society France.
5.	Mémoire sur la Formation Jurassique dans le Nord de la France, par M. E. Puillon Boblaye. Extrait des Annales des Sciences Naturelles, Mai 1829, 8vo. Paris, 1829.	The Author.
	Recherches sur les Roches designées par les Anciens sous les Noms de Marbre Lacedemonien et d'Ophites, par M. E. P. Boblaye, folio.	.....
8.	Bulletin de la Société Géologique de France, tome 4ème, feuilles 20–24, 8vo. Paris, 1834.	The Geological Society of France.
	Verhandlungen der Gesellschaft des vaterländischen Museums in Böhmen in der zwölften allgemeinen Versammlung, am 2 April, 1834, 8vo. Prag, 1834.	The President of the Museum of Prague.

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18.	Résumé des Progrès des Sciences Géologiques pendant l'Année 1833, par M. Ami Boué. Lu aux Séances des 17 et 24 Février, et 7 Avril 1834, tome 5ème du Bulletin de la Société Géologique de France, 8vo. Paris, 1834.	The Author.
	Contents of parts 2 and 3 of the Proceedings of the Royal Society of London, 1831–1833.	The Royal Society.
30.	Black, Young and Young's Catalogue of German Books and Maps which have been published from January to June 1834, 12mo.	Messrs. Black, Young and Young.
Sept. 1.	Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin, aus dem Jahre 1832 nebst der Geschichte der Akademie in diesem Zeitraum, 4to. Berlin, 1834.	The Berlin Academy.
18.	Principles of Geology, being an Inquiry how far the former Changes of the Earth's Surface are referable to Causes now in Operation, by Charles Lyell, Esq. For. Sec. G.S. 3rd Edition, in four volumes, 12mo. London, 1834.	The Author.
	Transactions of the American Philosophical Society, held at Philadelphia, for promoting Useful Knowledge. New Series, vol. 4, part 3, 4to. Philadelphia, 1834.	The American Philosophical Society.
20.	A Collection of Geological Facts and practical Observations intended to elucidate the Formation of the Ashby Coal Field, by Edward Mammatt, Esq. F.G.S. 4to. Ashby-de-la-Zouch, 1834.	The Author.
Oct. 16.	The American Journal of Science and Arts, conducted by Benjamin Silliman, M.D. For. Mem. G.S. vol. 26, No. 2, July 1834, 8vo. New Haven, 1834.	The Conductor.
24.	Memorie della Società Italiana delle Scienze residente in Modena, tomo 20, fascicolo secondo delle Memorie di Fisica, 4to.	The Society.
	Sul Problema dell' Equilibrio delle Volte. Memoria del Signor Dottore Vincenzo Amici, Coronata dalla Società Italiana delle Scienze residente in Modena, 4to. Modena, 1833.	The Author.
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	Elements of Chemistry, including the recent Discoveries and Doctrines of the Science, by Edward Turner, M.D. Sec.G.S. Fifth Edition, 8vo. London, 1834.	The Author.

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14.	Recherches sur les Ossemens Fossiles, découverts dans les Cavernes de la Province de Liége, par le Docteur P. C. Schmerling, 2ème partie, complétant le premier volume, 4to. Liége, 1833.	The Author.
	Mémoires de la Société de Physique et d'Histoire Naturelle de Genève, tome 6ème, parties 1 et 2, 4to. Genève, 1833.	The Society of Natural History of Geneva.
18.	The American Journal of Science and Arts, conducted by Benjamin Silliman, M.D. LL.D. vol. 27, No. 1, Oct. 8vo. New Haven, 1834.	The Conductor.
21.	The Fourteenth Report of the Council of the Leeds Philosophical and Literary Society, at the close of the Session 1833–1834, 8vo. Leeds, 1834.	The Leeds Philosophical and Literary Society.
	A Catalogue of the Fellows, Candidates and Licentiates of the Royal College of Physicians, 8vo. London, 1834.	The Royal College of Physicians.
28.	Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou, dédiés à S. M. l'Empereur Nicholas I. tome 3, 4to. Moscou, 1834.	The Imperial Society of Naturalists of Moscow.
	Bulletin de la Société Impériale des Naturalistes de Moscou, tome 6, 8vo. Moscou, 1833.	.....
	A Treatise on Nautical Surveying: containing an Outline of the Duties of the Naval Surveyor; with Cases applied to naval Evolutions and miscellaneous Rules and Tables useful to the Seaman or Traveller, by Commander Edward Belcher, R.N. 8vo. London, 1835.	The Author.
Dec. 3.	Observations Géologiques sur les deux Isles Baleares, Majorque et Minorque, par le Chevalier Albert de la Marmora, 4to. Turin, 1834.	The Author.
	Transactions of the Geological Society of Pennsylvania, vol. 1, part 1, 8vo. Philadelphia, 1834.	The Geological Society of Pennsylvania.
	A descriptive Catalogue of the Collection illustrative of Geology and Fossil Comparative Anatomy, in the Museum of Gideon Mantell, LL.D. F.G.S. 3rd Edition, 8vo. London, 1834.	Gideon Mantell, LL.D F.G.S.
	The Magazine of Natural History and Journal of Zoology, Botany, Mineralogy, Geology and Meteorology, conducted by J. C. Loudon, Esq. F.G.S. &c., for the Year 1834, 8vo.	The Conductor.
	The London and Edinburgh Philosophical Magazine and Journal of Science, conducted by Sir David Brewster, K.H. LL.D. F.G.S. &c., Richard Taylor, Esq. F.G.S. &c., and R. Phillips, Esq. F.G.S. &c., for the Year 1834.	The Conductors.

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5.	A Guide to Geology, by John Phillips, Esq. F.G.S. Professor of Geology in King's College, London, 12mo. London, 1834.	The Author.
11.	Transactions of the American Philosophical Society held at Philadelphia, for promoting Useful Knowledge, vol. 3, part 2. New Series, 4to. Philadelphia, 1834.	The American Philosophical Society.
12.	Rules and Regulations for the Government of the Athenæum, with an Alphabetical List of the Members, &c. 12mo. London, 1834.	The Committee of the Athenæum.
17.	Transactions of the Medico-Botanical Society of London, for 1832 and 1833, 8vo. London, 1834.	The Medico-Botanical Society.
	Experimental Researches in Electricity (Eighth Series), by Michael Faraday, Esq. F.G.S. &c. From the Philosophical Transactions, part 2, for 1834, 4to. London, 1834.	The Author.
	A Journey from Sydney to the Australian Alps, by Dr. John Lhotsky.	The Author.
	Geschichte der durch überlieferung nachgewiesenen natürlichen Veränderungen der Erdoberfläche ein Versuch, von Karl E.A. von Hoff, 3te Theil, 8vo. Gotha, 1834.	The Author.
	Lethæa Geognostica, oder Abbildung und Beschreibung der für die Gebirgs-Formationen bezeichnendsten Versteinerungen, von Dr. H. G. Bronn, 1ster Lieferung, Stuttgart, 1834.	The Author.
	Canal de Jonction entre le Rhin et le Danube, par Ch. Th. Kleinschrod. Traduit de l'Allemand, 8vo. Munich, 1834.	The Author.
	Bulletin de la Société Géologique de France, tome 4ème, feuilles 28 et 29, 8vo. Paris, 1834.	The Geological Society of France.
	The Philosophical Transactions of the Royal Society of London, for the Year 1834, part 2, 4to. London, 1834.	The Royal Society.
	Proceedings of the Royal Society of London, No. 17, May and June 1834, 8vo.	.....
	The Repertory of Patent Inventions, and other Discoveries and Improvements in Arts, Manufactures and Agriculture. New Series, for the Year 1834, 8vo. London, 1834.	The Editor.
	Annales des Mines, ou Recueil de Mémoires sur l'Exploitation des Mines, et sur les Sciences et les Arts qui s'y rapportent, rédigées par les Ingénieurs des Mines, et publiées sous l'Autorisation du Conseiller d'Etat, Directeur Général des Ponts et Chaussées et des Mines, 3ème Série, tome 6, 5ème livraison, 8vo. Paris, 1834.	L'Administration des Mines.

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Jan.	3.	M. A. Nattali's Catalogue of Books in various Languages, for the Year 1835, 8vo. London, 1834.	Mr. M. A. Nattali.
	9.	T. Rodd's Catalogue of Books for the year 1835, 8vo.	Mr. T. Rodd.
		Descriptive and illustrated Catalogue of the Physiological Series of Comparative Anatomy contained in the Museum of the Royal College of Surgeons in London, vol. 2, including the Absorbment, Circulating, Respiratory, and Urinary Systems, 4to. London, 1834.	The Royal College of Surgeons.
	26.	Transactions of the Society for the Encouragement of Arts, Manufactures and Commerce, for the Session 1833–1834, being part 1 of vol. 50, 8vo. London, 1834.	The Society of Arts.
		Records of General Science, by Robert D. Thomson, M.D. with the Assistance of Thomas Thomson, M.D. F.G.S. Regius Professor of Chemistry in the University of Glasgow, No. 2, February 1835, 8vo. London, 1835.	The Editor.
		On the Structure of the Teeth, in the "Edentata," fossil and recent, by Richard Harlan, M.D. Read April 28th, 1834. From the Transactions of the Geological Society of Pennsylvania, vol. 1.	The Author.
		Critical Notices of various organic Remains hitherto discovered in North America, by Richard Harlan, M.D. Read May 21st, 1834. From the Transactions of the Geological Society of Pennsylvania, vol. 1.	.....
		Bohn's Catalogue of Ancient and Modern Books in all Classes of Natural History, Agriculture, Gardening, Mining, Hunting, Hawking, Fishing, &c. 8vo. London, 1835.	Mr. John Bohn.
		Arboretum Britannicum; or the Hardy Trees of Britain, native and foreign, pictorially and botanically delineated, and scientifically and popularly described, &c., by J. C. Loudon, Esq. F.G.S. Nos. 1 and 2, 8vo. London, 1835.	The Author.
		Dictionnaire Géographique de la Province d'Anvers, et Dictionnaire Géographique de la Province de la Flandre Orientale, par M. Ph. Vander Maelen, 2 vols. 8vo. Bruxelles, 1834.	M. Ph. Vander Maelen.
		Proceedings of the Royal Society of London, No. 18, Nov. 1834.	The Royal Society.
Feb.	1.	Journal of the Royal Geographical Society, vol. 4, part 2, 8vo. London, 1835.	The Royal Geographical Society.
		A Letter to James Jameson, Esq., by Charles Waterton, Esq. of Walton Hall, 8vo. Wakefield, 1835.	The Author.
		On the Freshwater Limestone of Burdiehouse, in the Neighbourhood of Edinburgh; with Supplementary Notes on other Freshwater Limestones, by Samuel Hibbert, M.D. F.G.S. From the Transactions of the Royal Society of Edinburgh, vol. 13, part 1, 4to. Edinburgh, 1835.	The Author.

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	A second Copy of the same Number was presented by the Editor, March 7th.	
	Analysis of Coprolites and other organic Remains imbedded in the Limestone of Burdiehouse, near Edinburgh, by Arthur Connell, Esq. From the Transactions of the Royal Society of Edinburgh, vol. 13, 4to. Edinburgh, 1835.	The Author.
	On the Satellites of Uranus, by Sir J. F. W. Herschel, Knt. Guelp. F.G.S. From the Memoirs of the Royal Astronomical Society, vol. 8, 4to. London, 1834.	The Author.
	A List of Test Objects, principally double Stars, arranged in Classes, for the trial of Telescopes in various Respects, as to Light, Distinctness, &c., by Sir J. F. W. Herschel, Knt. Guelp. F.G.S. From the Memoirs of the Royal Astronomical Society, vol. 8, 4to. London, 1834.	The Author.
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	Transactions of the American Philosophical Society, held at Philadelphia, for promoting Useful Knowledge, vol. 5. New Series, part 1, 4to. Philadelphia, 1834.	The American Philosophical Society.
	Bulletin de la Société Géologique de France, tome 6, feuilles 1–4, 8vo. Paris, 1835.	The Geological Society of France.
	Raccolta di Osservazioni Cliniche sull' Uso dell' Acqua Termo-Minerale Vesuviana-Nunziante, Fatte da varii Professori del 1832, fascicolo primo, 8vo. Napoli, 1833.	Charles Daubeny, M.D. F.G.S.
	Raccolta di Osservazioni intorno gli Effetti Terapeutici e le Cure per l'Acqua Termo-Minerale Vesuviana-Nunziante corrente l'Anno 1833. Preceduta da una Memoria scritta dal Professore Guiseppe Ricci, fascicolo secondo, 8vo. Napoli, 1834.	.....
Mar. 2.	A History of British Fishes, by William Yarrell, F.L.S. part 1, 8vo. London, 1835.	The Author.
3.	The West of England Journal of Science and Literature, edited by George T. Clark, No. 1, January 1835, 8vo. Bristol, 1835.	The Editor.
	Journal of the Academy of Natural Sciences of Philadelphia, vol. 7, part 1, 8vo. Philadelphia, 1834.	The Academy of Natural Sciences of Philadelphia.
	List of the Members of the Zoological Society of London, June 1st, 1833, 8vo. London, 1833.	The Zoological Society.

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Mar. 7.	Supplement to the List of the Members of the Zoological Society, June 1834.	The Zoological Society.
	List of the Members of the Royal Asiatic Society of Great Britain and Ireland, 1834. 8vo.	The Royal Asiatic Society.
	List of the Members of the Royal Society of London, 1st Dec. 1834, 4to.	The Royal Society.
	Report on the Adjudication of the Copley, Rumford, and Royal Medals; and appointment to the Bakerian, Croonian, and Fairchild Lectures. 4to. London, 1834.	.....
	List of the Members of the Society of Antiquaries of London. 4to. 1834.	The Society of Antiquaries.
	List of the Members of the Linnean Society of London. 4to. 1834.	The Linnean Society.
	List of the Members of the Horticultural Society of London. 4to. 1834.	The Horticultural Society.
21.	The American Journal of Science and Arts, conducted by Benjamin Silliman M.D. LL.D., vol. 27, No. 2. 8vo. New Haven, 1835.	The Conductor.
	Transactions of the Royal Society of Edinburgh, vol. 13, part 1. 4to. Edinburgh, 1835.	The Royal Society of Edinburgh.
	Proceedings of the Royal Society of Edinburgh, No. 4, January to April, 1834. 8vo.	.....
23.	Bibliographia Palæonthologica Animalium systematica. Auctore Gotthelf Fischer de Waldheim. Editio altera, aucta, jussu Societatis Cæsareæ Naturæ Scrutatorum impressa. 8vo. Mosquæ, 1834.	The Author.
26.	The Journal of the Royal Asiatic Society of Great Britain and Ireland, No. 2. 8vo. London, 1834.	The Royal Asiatic Society of Great Britain and Ireland.
April 3.	Voyage dans l'Amérique Méridionale commençant par Buénos Ayres et Potosi jusqu'à Lima, par Antoine-Zachaire Helms, traduit de l'Anglais. 8vo. Paris, 1815.	John Willimott, Esq. F.G.S.
6.	The Entomological Magazine, Nos. 6–9 for January to October 1834, and Nos. 10 and 11 for January and April 1835. 8vo. London.	F. Walker, Esq. F.G.S.
	Illustrations of the Botany and other Branches of the Natural History of the Himalayan Mountains, and of the Flora of Cashmere; by J. Forbes Royle, Esq., F.G.S., &c. parts 1 to 5. fol. London, 1834, 1835.	The Author.
	Memoirs of Ichthyosauri and Plesiosauri, extinct Monsters of the Ancient Earth; by Thomas Hawkins, Esq. F.G.S. fol. London, 1834.	The Author.
	Transactions of the Zoological Society of London, vol. 1, part 3. 4to. London, 1835.	The Zoological Society.
	A memoir on Clavagella; by W. J. Broderip, Esq., V.P.G.S. From the Transactions of the Zoological Society, vol. 1. 4to.	The Author.
	Descriptions of some New Species of Calyptræidæ; by W. J. Broderip, Esq., V.P.G.S. From the Transactions of the Zoological Society, vol. 1. 4to.	.....

1835.	BOOKS.	DONORS.
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	Report of the Directors of the Manchester Mechanics' Institution, and Proceedings at the Annual Meeting of the Members held in the Theatre of the Institution on Thursday, 26th February, 1835. 8vo.	The Manchester Mechanics' Institution.
	A Catalogue of the Library of the Manchester Mechanics' Institution, with the Rules and a Sketch of the Objects and Advantages of the Institution. 8vo. Manchester, 1834.	.....
28.	The Chemical Catechism, by the late Samuel Parkes, F.G.S. &c. &c. Thirteenth Edition; revised and adapted to the present state of Chemical Science by E. W. Brayley, Jun. 8vo. London, 1834.	The Editor.
29.	Illustrations on the Botany and other Branches of the Natural History of the Himalayan Mountains and of the Flora of Cashmere; by John Forbes Royle, Esq. F.G.S. &c. part 6. folio. London, 1835.	The Author.
	Proceedings of the Royal Society of London, No. 19 December 1834 to March 1835. 8vo.	The Royal Society.
May 1.	Experimental Researches in Electricity (Ninth Series); by Michael Faraday, Esq. D.C.L. F.G.S. &c. From the Philosophical Transactions, part 1. for 1835. 4to. London, 1835.	The Author.
	Arboretum Britannicum, or, the Hardy Trees of Britain Native and Foreign, pictorially and botanically delineated, and scientifically and popularly described; by J. C. Loudon, Esq. F.G.S. No. 5, May. 8vo. London, 1835.	The Author.
	Ueber Terebrateln mit einem Versuch, sie zu classificiren und zu beschreiben; von Leopold von Buch, Eine in der Königlichen Akademie der Wissenschaften gelesene Abhandlung. fol. Berlin, 1834.	The Author.
	Nouvelles Annales du Muséum d'Histoire Naturelle, ou Recueil de Mémoires publiés par les Professeurs de cet Établissement et par d'autres Naturalistes sur l'Histoire Naturelle, l'Anatomie, et la Chimie, tomes 1 à 3. 4to. Paris, 1832–1834.	L'Administration du Muséum d'Histoire Naturelle de Paris.
4.	Mr. M. A. Nattali's Catalogue of Books for May 1835. 8vo.	Mr. Nattali.
	A Guide to Geology; by John Phillips, Esq. F.G.S. Professor of Geology in King's College, London. 2nd Edition. 12mo. London, 1835.	The Author.
	Sketch of the Geology and Mineralogy of New London and Windham Counties in Connecticut; by Wm. W. Mather. 8vo. Norwich, U.S., 1834.	The Author.

1835.	BOOKS.	DONORS.
May 12.	An Address delivered at the Fourth Annual Meeting of the Geological Society of Dublin, on the 11th of February, 1835, by Richard Griffith, Esq. F.G.S. President of the Society: to which is subjoined the Annual Report, &c. &c. 8vo. Dublin, 1835.	T. H. Holdsworth, Esq. F.G.S.
	Notice as to the supposed Identity of the large Mass of Meteoric Iron now in the British Museum, with the celebrated Otumpa Iron described by Rubin de Celis in the Philosophical Transactions for 1786; by Woodbine Parish, Jun., Esq. F.G.S. From the Philosophical Transactions, part 1. for 1834. 4to. London, 1834.	The Author.
21.	The American Journal of Science and Arts, conducted by Benjamin Silliman, M.D. LL.D. vol. 28, No. 1, April, 1835. 8vo. New Haven, 1835.	The Conductor.
27.	Notices on the Bolivian Andes, and Southern Affluents of the Amazons, communicated to the Royal Geographical Society by J. B. Pentland, Esq. and Woodbine Parish, Jun. Esq. F.G.S. From the Journal of the Royal Geographical Society. 8vo. 1835.	The Communicators.
	"How to Observe" Geology; by H. T. De la Beche, Esq. For. Sec. G.S. 8vo. London, 1835.	The Author.
30.	Synopsis of the Organic Remains of the Cretaceous Group of the United States; by Samuel George Morton, M.D. 8vo. Philadelphia, 1834.	The Author.
	The Repertory of Patent Inventions, and other Discoveries and Improvements in Arts, Manufactures and Agriculture. New Series for the Year 1835. 8vo. London, 1835.	The Editor.
June 2.	Revelation and Science: the Substance of a Discourse delivered before the University of Oxford at St. Mary's, March 8th, 1829, with some additional Remarks occasioned by the publication of the Bampton Lectures for 1833 and other recent Works; by the Rev. Baden Powell, M.A. Savilian Professor of Geometry in the University of Oxford. 8vo. Oxford, 1833.	The Rev. James Yates, F.G.S.
4.	Instructions for making and registering Meteorological Observations in Southern Africa, and other countries in the South Seas, as also at Sea. 8vo.	The South African Literary and Philosophical Institution.
	The Cyclopædia of Anatomy and Physiology; edited by Robert B. Todd, M.B. part 1, published by Sherwood and Co. 8vo. London, 1835.	The Publishers.
5.	Arboretum Britannicum, or, the Hardy Trees of Britain, Native and Foreign, pictorially and botanically delineated, and scientifically and popularly described, by J. C. Loudon, No. 6, June. 8vo. London, 1835.	The Conductor.
	Volcanic Geology, by Professor Daubeny, M.D. F.G.S. From the Encyclopædia Metropolitana 4to.	The Author.

1835.	BOOKS.	DONORS.
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	The Horticultural Register and General Magazine of all Useful and Interesting Discoveries connected with Natural History and Rural Subjects ; conducted by Joseph Paxton, from January to June 1835. 8vo. London, 1835.	The Conductor.
	The Magazine of Natural History and Journal of Zoology, Botany, Mineralogy, Geology and Meteorology ; conducted by J. C. Loudon, Esq. F.G.S. From January to June 1835. 8vo. London, 1835.	The Conductor.

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	An Impression of the engraved Portrait of the Rev. Prof. Sedgwick.	Thomas Phillips, Esq. R.A.
1834.		
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1835.		
Mar. 31.	An Impression of a Lithographic Drawing of *Calymene arachnoides.*	M. F. Wm. Hoeninghaus.

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	The N.E. quarter sheet of the 63rd sheet of the Ordnance Survey, coloured geologically by H. Still, Esq. employed in the Ordnance Survey.	Henry Still, Esq.

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	Copper Slags from Swansea.	.....
Sept. 10.	Specimens from the Mountain Limestone in the neighbourhood of Tenby.	The Rev. T. Salway.
30.	Bones of the Elephant, Rhinoceros, and Ox, from the gravel, Brockhall Lawford.	The Rev. Wm. Thornton.
	Fossils from the Cliffs at Hastings and St. Leonards, and a Tree from the Submarine Forest near St. Leonards.	Woodbine Parish, Jun. Esq. F.G.S.
	Specimens of *Endogenites erosa* from St. Leonards.	Wm. Henry Fitton, M.D. V.P.G.S.
	Specimens from the Submarine Forest near Hastings.	Robert Wrench, Esq.
	Specimens of Wood perforated by a Pholas.	Capt. Belcher, R.N. F.G.S.
	Specimen of Thorit.	Prof. Esmark, For. Mem. G.S.
Nov. 6.	Three Fishes from the Magnesian Limestone, Thickley.	Wm. P. Cumby, Esq.
	Specimens of *Cyrtoceratitis costatus* from Gerolstein.	M. J. W. Hoeninghaus.
17.	A series of specimens from the North Shore of the River St. Lawrence.	Capt. Bayfield, R.N.
	Specimens of Lead Ore, from Gador, South of Spain.	John Willimot, Esq. F.G.S.
	Specimen of Fossil Wood perforated by *Teredina personata.*	Henry C. White, Esq. F.G.S.
	Specimens from Vesuvius, Calabria, Sicily and Mount St. Gothard, &c.	Count Bylandt.
	A Specimen of Marble perforated by Lithodomi obtained from a Ship sunk in the Leghorn Roads in the year 1750.	W. Richardson, Esq. F.G.S.
	A specimen of rock salt from Huamanga between Huancavelica and Cusco.	J. M. Maclean, Esq.
	A collection of specimens made in the crater of Vesuvius.	John Auldjo, Esq. F.G.S.
Dec. 4.	Chromate of Lead from Siberia.	Mons. Donati.
18.	Specimens from Malta.	J. W. Collings, Esq.
	A specimen of the Hastings sandstone.	Charles, Babbage, Esq.

1833.		SPECIMENS.	DONORS.
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		Specimens from the Azores.	The Rev. J. H. Simpson.
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		Specimens from Jersey.	Ashurst Magendie, Esq. F.G.S.
1834.			
Jan.	8.	Specimens from the Old Red Sandstone of South Wales.	Roderick I. Murchison, Esq. F.G.S.
	22.	Casts of perforations by *Teredina personata* from the Plastic Clay, Hengisbury, Hants.	The Rev. Prof. Buckland, D.D. F.G.S.
		Suite of rocks and fossils to illustrate Mr. Murchison's paper on "Herefordshire, Shropshire, and parts of Wales."	R. I. Murchison, Esq. F.G.S.
		Specimens from Australia.	Capt. H. Smyth, 39th Regt.
Feb.	5.	Casts of the Bones of the Megatherium from Buenos Ayres, brought home by Woodbine Parish, Jun. Esq. F.G.S.	The Royal College of Surgeons.
		Casts of the Inferior and Maxillary Bones of the Mastodon and Tetracaulodon.	The American Philosophical Society.
		Specimens from the Coal-Field of Wyre Forest.	The Rev. Thos. England, F.G.S.
	26.	Fossils from the Plastic Clay near Reading.	John Rofe, Jun. Esq.
		Specimens from the Islot of Alcatraz on the West Coast of Africa, and from Gibraltar and Keith's Reef between Sicily and the coast of Africa.	Capt. Belcher, R.N. F.G.S.
		Fossil Plants, Insects and Fishes from Aix in Provence.	Geo. Bentham, Esq. F.G.S.
		Specimens of Lignite from Leira.	Richard Hollier, Esq. F.G.S.
Mar.	12.	Specimens from France.	R. I. Murchison, Esq. V.P.G.S.
		Corals from Aymestry.	The Rev. T. T. Lewis.
	25.	Cast of an Ophiura; from the Lias, banks of the Severn.	Mathew Wright, Esq. F.G.S.
		Specimens of plants from the Greensand Formation of Niedershöna near Freyberg.	M. Felipe Bauza, Jun.
		An Hippurite from Sicily.	M. le Comte Duchatel.
		Additional specimens from the Eifel.	Leonard Horner, Esq. F.G.S.
		Specimens of the Southstone Roche near Tenbury, Worcestershire.	R. I. Murchison, Esq. V.P.G.S.
April	9.	Specimens from the Mountain Limestone and Greensand of England.	.....
		Fossil Fishes from Monte Bolca.	Wm. A. Mackinnon, Esq.
		Specimens from Port Macquarie.	Capt. H. Smyth, 39th Regt.
		Selenite from the London Clay near Herne Bay.	W. Richardson, Esq. F.G.S.
	14.	Portions of Septaria from the London Clay at Brixton, and Fossil Wood perforated by *Teredina personata*.	The Rev. Prof. Buckland, D.D. F.G.S.
	18.	Native Iron from the Mass in the British Museum from Otumpa in the Chaco, South America.	Woodbine Parish, Jun. Esq. F.G.S.
	23.	Specimens from the Tertiary Formations of Murcia.	Chas. Silvertop, Esq. F.G.S.
	25.	Specimens of *Pentamerus oblongus*.	Mr. Rees.

1834.	SPECIMENS.	DONORS.
April 25.	Fossils of the Grauwacke Series of Shropshire.	W. Williams, Esq.
	Fossils from the Grauwacke of the neighbourhood of Llandovery.	Prof. Miller, F.G.S.
	A large specimen of the polished Limestone found near Gwinfe in Caermarthenshire.	The Rev. T. T. Lewis.
May 1.	Cast of a Palatal Bone from the Chalk.	Nathaniel Wetherell, Esq. F.G.S.
	Specimens of Rowley Rag, unaltered, decomposed and fused.	John Corrie, M.D. F.G.S.
12.	Lava from Graham's Island.	Capt. Stewart.
21.	Specimens of Greenstone, Porphyry and Sienite from the Border Counties of England and Wales.	R. I. Murchison, Esq. V.P.G.S.
June 1.	Specimens from the Hastings sand.	Baden Powell, Esq. F.G.S.
	Specimens from Spain.	Capt. Cook, R.N. F.G.S.
	Slickensides, from Cornwall.	R. Taylor, Esq. F.G.S. of Perran, Arworthal.
3.	Fish from the Magnesian Limestone.	J. W. Colling, Esq.
4.	Specimens from the Mines of Konigsberg, Norway.	H. C. Ström, Esq. Engineer of Mines.
	A specimen of artificial cupriferous Iron Pyrites.	.....
	Fish from Monte Bolca.	S. P. Pratt, Esq. F.G.S.
	Carbonate of Strontia with calcareous Spar and Brown Iron Ore, Forest of Dean.	Capt. Yorke, R.N.
	Minerals from the Trap of Scotland.	G. B. Greenough, Esq. Pres.G.S.
	Corals from the Shale beds of the Mountain Limestone, County of Fermanagh.	Viscount Cole, M.P. F.G.S. and Sir Philip Egerton, Bart. F.G.S.
	Casts of the Remains of *Felis spelæa* and *Gulo spelæus* from Gailenreuth.	.....
	Magnetic Iron Ore from Sierra Leone.	David Mushet, Esq. H.M. G.S.
21.	Specimens from Tampico.	Thos. Weaver, Esq. F.G.S.
	Specimens taken from the crater of the Water Volcano near Guatemala.	Col. Galindo.
July 3.	A Fossil Crab from India (*Gonoplax Latreillii*).	The Right Hon. the Earl of Cawdor, F.G.S.
7.	Fossils from the neighbourhood of St. Ives.	J.R. Wright, Esq. F.G.S. and H. Machlauchlan, Esq. F.G.S.
20.	Specimens from the London Clay at Hornsey.	N. T. Wetherell, Esq. F.G.S.
Aug. 14.	Specimens from the Channel Islands.	W.C. Trevelyan, Esq. F.G.S.
	Cast of a claw-bone of a Crocodile, and of an Iguanodon from Tilgate Forest.	Gideon Mantell, Esq. F.G.S.
Nov. 5.	Cast of a Palatal Tooth from the Chalk of Dorsetshire.	The Rev. Prof. Buckland, D.D. F.G.S.
12.	Specimens from the Loam of Muswell Hill; and additional specimens from a well at Hornsey.	N. T. Wetherell, Esq. F.G.S.
13.	Remains of *Anthracotherium Velaunum*, Myoxus and Crocodile from Puy en Velay.	M. Bertrand de Doue, For. Mem. G.S.

1834.		SPECIMENS.	DONORS.
Nov.	13.	Fossils from Bognor and the Chalk near Felpham.	Woodbine Parish, Jun. Esq. F.G.S.
		Palatal Teeth of an Eagle Ray, (Myliobatis, Cuv.) from Bermuda.	LeonardS.Coxe,Esq.F.G.S.
		Specimens of recent Coral from the Straits of Sunda.	Woodbine Parish, Jun. Esq. F.G.S.
		Specimens from the Big Bend on the Missouri.	HenryD.Rogers,Esq.F.G.S.
		Tertiary Shells from the United States.	.....
		Specimens from the Ancient Beach at Hope's Nose near Babbacombe and from the Watcomb Fault, Devonshire.	Robert A. Austen, Esq. F.G.S.
Dec.	2.	Specimens from China.	John R. Reeves, Esq.
		Specimens of Granite traversed by veins, from Dartmoor.	J. H. Deacon, Esq. F.G.S.
		Vegetable Remains from the Anthracite of North Devon.	Henry T. De la Beche, Esq. F.G.S.
		Specimens from Australia.	A. Cunningham, Esq.
	4.	Anthracite from the Lehigh Coal Mine, Pennsylvania.	F. Lambert, Esq.
		Palatal Tooth of a Fish from the Chalk.	John Dickinson, Esq. F.G.S.
		Fossils from the Greensand near Lyme.	Viscount Cole, M.P. F.G.S. and Sir Philip Egerton, Bart. F.G.S.
		Hippurite from Untersberg.	R. I. Murchison, Esq. V.P.G.S.
		Cast of a Molar Tooth of *Mastodon angustidens* from the Crag, Suffolk.	Hugh E. Strickland, Esq. F.G.S.
	18.	Shells from the Loam and Gravel near Cropthorne, Worcestershire.	.....
	22.	Fossils from the neighbourhood of Ilfracombe.	Col. Harding.
		Specimens from the Coal of the South of Ireland.	ThomasWeaver, Esq.F.G.S.
1835.			
Jan.	21.	Fossils from the Calcaire Grossiere of France.	J. Prestwich, Jun. Esq. F.G.S.
		Casts from Flambro' Head of Spongeous Zoophites.	— Leigh, Esq.
		Shells and Bones of Mammalia from Stutton, Suffolk, and a Specimen of the Calcareous Nodules accompanying the Shells.	Edward Charlesworth, Esq.
		Specimens of Lias from Cloverly and of the New Red Sandstone Series of Shropshire.	R. I. Murchison, Esq. V.P.G.S.
Feb.	3.	Porcelain Jasper from the Junction of the Sandstone and Trap Rock of Stirling Castle.	Richard Knight, Esq. F.G.S.
		Flexible Magnesian Limestone from Sunderland, and Fossils from the Lower Greensand, Kent.	John Willimott, Esq. F.G.S.
		A Specimen of Franklinite from New Jersey, and of Shelly Ironstone from Lake Möllor between Hamburgh and Lubeck.	.....
		Fossils from the Greensand, Blackdown.	Viscount Cole, M.P. F.G.S. and Sir Philip Egerton, Bart. M.P. F.G.S.
Mar.	1.	Casts of bones of the *Megalonyx laqueatus* from Big-bone Cave in Tennessee.	Richard Harlan, M.D.

1835.		SPECIMENS.	DONORS.
Mar.	1.	Specimens from the Silverdale Mines, Staffordshire.	Sir Philip Egerton, Bart. M.P. F.G.S.
April		Shells of existing species from the Newer Pliocene Deposits in the Baltic.	Charles Lyell, Esq. P.G.S.
		Specimens from the Isle of Portland.	W. H. Fitton, M.D. F.G.S.
	29.	Specimens from Chili, Peru and the Island of Juan Fernandez.	H. Cuming, Esq.
		Specimens of British and Foreign Minerals.	T. H. Holdsworth, Esq. F.G.S.
		Specimens from the Island of Ascension, the Mauritius, &c.	The Rev. W. P. Hennah.
May		Specimens from the Pennant Grit and Dolomitic Conglomerate near Bristol.	George Cumberland, Esq. Hon. Mem. G.S.
		Silicified Wood from the Portland Stone at Chicksgrove, Wilts.	Miss Benett, of Norton House.
		A Stalactite from Ingleborough Cave, Yorkshire.	Woodbine Parish, Jun. Esq. F.G.S.
	14.	A specimen of Shale with impressions of Fern Leaves from the Grit Formation near Wodwowitz, Prussia.	M. John B. Batka, of Prague.
		A Fish from the Purbeck beds, in the Vale of Wardour.	Miss Benett.
		Minerals and Rock Specimens from Norway.	M. H. C. Ström.
		Casts of an Occipital Bone, and the anterior Cervical Vertebræ of the Ichthyosaurus lately found near Lyme Regis.	H. Warburton, Esq. M.P. F.G.S.
June	10.	Specimens from the Mountain Limestone near Frome.	Miss Benett.
		Specimens of Fossils from the Coal Strata near Keighley, in Yorkshire.	The Rev. Theodore Dury.
		Specimens from the Diluvium at Lawfurd.	The Rev. Wm. Thornton, F.G.S.
		Specimens of Spirolinites in Chalk Flints from Stoke, near Chichester.	The Marquis of Northampton, F.G.S.
		A set of Teeth of the Gangetic Crocodile.	N. T. Wetherell, Esq. F.G.S.
		Specimens from the Arigna Mines.	John Rofe, Jun. Esq. F.G.S.
		Specimen of a Trilobite from Dudley.	— Rofe, Esq.

IV. *Miscellaneous.*

1833.		MISCELLANEOUS.	DONORS.
Aug.		Glass Models to promote the study of Crystallography.	M. J. B. Batka.
		A Medal of Berzelius in Selenium.	.....
1834.			
Feb.	5.	A Silver and a Bronze Medal of Count Casparus Sternberg.	Count Sternberg, For. Mem. G.S.
June	4.	Specimens of Iron Tubes from a Steam Boiler, Cornwall.	John Taylor, Esq. Treas. G.S.
Dec.	6.	Deposits on the vertical walls of the Boiler of a Steamboat.	Charles Lyell, Esq. For. Sec. G.S.

PLATES AND MAPS

IN ILLUSTRATION

OF

VOLUME IV.

SECOND SERIES,

OF

THE TRANSACTIONS

OF

THE GEOLOGICAL SOCIETY

OF LONDON.

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SOLD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY,
SOMERSET HOUSE.

1837.

EXPLANATION OF THE PLATES.

Plates I., II. & III.

Illustrate Dr. Buckland and Mr. De la Beche's paper on the Geology of the neighbourhood of Weymouth and the adjacent parts of the coast of Dorset.

Plate I.

Geological Map of the neighbourhood of Weymouth and the adjacent parts of the coast of Dorset.

The reader is requested to take notice that the authors do not profess to mark the exact limits of the lower Purbeck Beds in Portland, but merely to indicate their presence as the uppermost formation in the north end of that island.

Plate II.

Series of Sections.—Colours the same as in the Map.

Fig. 1. Section from the Great fault near Upway to the Bill of Portland*.

Fig. 2. Section from the Great fault near Moigne's Down Farm to Ringstead Bay.

Fig. 3. Section from the Great fault near Poxwell to the signal station near Osmington Mills.

Fig. 4. Section from the Great fault near Sutton to the Sea at Ham Cliff.

Fig. 5. Section from the Great fault near Sutton to Jordon Hill in Weymouth Bay.

Fig. 6. Section from Abbotsbury Common over Linton Hill.

Fig. 7. Section from Abbotsbury Castle to Abbotsbury Swanery, showing the continuation of the Great fault.

Fig. 8. Coast section from Jordon Hill to near Boat Cove. The apparent curvature in the Oxford Clay and other strata at the east end of this section arises from an indentation of the coast: the strata have an E. and W. direction throughout, and dip rapidly N., and have not the bend here represented, by throwing the curves of the coast into a straight line.

Fig. 9. Coast section from near the termination of fig. 8 to Ringstead Bay. As the coast ranges along the line of direction of the strata, its indentations give these strata a false appearance of dipping in different directions: they form a small arch at Osmington Mills.

* The Scale (in length) of fig. 1. is one inch to the mile; of fig. 2. to 10. inclusive, two inches to the mile: figs. 11. to 13. inclusive are on a larger scale, and fig. 14. two inches to the mile.

Fig. 10. Coast section near White Nore.

Fig. 11. Fault in the Cliffs, a little W. of White Nore.

Fig. 12. Theoretical diagram representing the manner in which different rocks may be seen in contact, in consequence of various degrees of denudation, on the same fault. Illustrations of this may be found in Sutton Valley;—where there is little or no denudation, the Portland Stone and Chalk are in contact at the surface; where a denudation occurs to the depth of the curved line *a a*, the Portland Stone and Green Sand are in contact, on opposites sides of the fault; at the depth *b b*, the Portland Sand and green sand touch each other; and at the depth *c c*, the Kimmeridge clay touches green sand.

Fig. 13. Fault in the cliff west of Bridport Harbour.

Fig. 13 *a*. Eastern termination of the Bridport Harbour fault.

Fig. 14. Section from the cliff west of Bridport Harbour to Askerswell.

Plate III.

Fig. 1. Tabular and proportional view of the strata in the Weymouth district.

a. Angular flints and plastic clay.

b. Chalk.

c. Chalk interspersed with grains of green earth (Craie chloritée).

d. Indurated green sand, with quartz grains and quartzose sandstone.

e. Greenish brown sands with indurated concretions.

f. Light brown sands. Fox mould.

g. Green sandy marl beds, with nodules similar to the cow-stone at Lyme Regis.

h. Purbeck beds.

i. Dirt bed, above the Portland beds, frequently contains rolled calcareous pebbles, and fossil silicified trunks of large coniferous trees, and of Cycadeoideæ.

k. Best beds of the Portland Stone.

l. Compact light-coloured limestone, with beds, seams, and nodules of chert.

m. Grey shelly beds, the base of the Portland Stone.

n. Green, brown, and grey sands and sandstones.

o. Brown and grey sandy marls, with indurated nodules.

p. Kimmeridge clay, contains an abundance of deltoid oysters.

q. Clay ironstone in the lower part of the Kimmeridge clay.

r. Upper grit beds, containing deltoid oysters: these beds are most fully developed near Sandfoot Castle.

s. Oolite differently developed in different places.

t. Brown sands, containing indurated nodules of calcareous sandstone.

u. Grey clay.

v. Larger deposit of calcareous grit, containing *Gryphæa dilatata*.

w. Oxford clay, grey marl, abounding in *Gryphæa dilatata*.

x. Rubbly and slaty Cornbrash limestones, alternating with clays and marls.

y. Slaty and shelly grey and brown limestones, containing *Apiocrinites rotundus*, lignite, broken shells, &c.

z. Grey marl, with marlstone in its lowest region.

a a. Coarse granular limestone, loaded with grains and veins of hydrate of iron.

b b. Light brown and yellow calcareo-siliceous sands and sandstones, often highly micaceous.

Fig. 2. Section showing details of the Oxford oolite near the east extremity of Weymouth Bay.

Fig. 3. Detailed section of the strata that occur in the Isle of Portland.

Note.—Since the paper was printed to which these sections refer, a notice has appeared in the London and Edinburgh Philosophical Magazine, August 1, 1833, p. 158, by Mr. R. Phillips, containing a minute analysis of the water of two sulphureous springs of similar quality near Weymouth, both of which issue from near the junction of the lower beds of the Oxford clay with the cornbrash or upper beds of the Forest Marble Formation. One is situated at Nottington, about three miles on the North of Weymouth, and was described by Dr. Pickford in a small treatise printed at Weymouth in 1821. The other rises at Radipole, about one mile from Weymouth, and was discovered but a short time ago. The most important of the ingredients of these mineral waters is sulphuretted hydrogen, which is derived from the passage of the water through strata that contain iron pyrites in a state of decomposition. Mr. Phillips remarks that "the saline contents of these waters are so small in quantity, that they must be considered as quite inert, and therefore those who wish to avail themselves merely of the sulphuretted hydrogen, may take them in larger quantity than if they were active in other respects.

Plates IV. & V.

Illustrate Professor Sedgwick's paper introductory to the General Structure of the Cumbrian Mountains, with a description of the great dislocations by which they have been separated from the neighbouring carboniferous chains: p. 47.

Plate IV.

Map exhibiting the geological structure of the district, and the range of the band of limestone and calcareous slate between the quartzose green slate and the greywacké slate.

Plate V.

Sections exhibiting some of the great dislocations produced by the elevation of the northern carboniferous chain: p. 59.

Plate VI.

Illustrates Professor Sedgwick's paper on a Series of longitudinal and transverse sections through a portion of the carboniferous chain between Penigent and Kirkby Stephen: p. 69.

EXPLANATION OF THE PLATES.

Plates VII. to XXIII.

Illustrate Dr. Fitton's paper "On some of the strata between the Chalk and the Oxford "Oolite, in the South-east of England": p. 103, to 378.

Plate VII.

Contains small portions of the *Maps* of *Kent*, *Surrey*, and *Wiltshire*, reduced to half the scale of the Ordnance Survey.

Fig. 1. Part of the *Coast of Kent*: p. 105—119.

Fig. 2. Part of *Surrey*: p. 137—142.

Fig. 3. The *Vale of Wardour*, South Wiltshire: p. 245—254.

Plate VIII.

A Sketch of part of the *Coast of Kent*, from *Hythe* to *Folkstone Hill*; reduced from a drawing by the Rev. J. D. Glennie: p. 108—127.

Plate IX.

Map of part of the *South East of England*, and of the opposite *Coast of France*, on the same scale with Mr. Gardner's reduced Geological Map of England; about 18 miles to an inch. The space occupied by strata above the chalk is taken from Mr. Greenough's Map. The divisions below the chalk are inserted from the information stated in the present paper, and will be given on a larger scale in the new edition of Mr. Greenough's Geological Map. The *continuous red* lines, numbered 1. to 25., refer to the sections described in this paper, and represented in Plate X. a. The *dotted* lines adjacent to Nos. 15. and 16. represent the course of Mr. Lonsdale's sections, (Geol. Trans. 2nd Series, vol. iii. pl. 32.); and those adjoining Nos. 18 and 21, are *transverse* sections in Oxfordshire and Bucks. The *blue* lines denote some of the anticlinal lines; those in the vicinity of Bristol are from Messrs. Buckland and Conybeare's map, (Geol. Trans. 2nd Series, vol. i. pl. 38.); the rest from the statements of the present paper.

On the French coast, from Calais to Treport, the colours are inserted from the manuscript notes of the author: In the Pays de Bray, and thence to the mouth of the Seine and coast of Normandy, they are taken principally from M. Passy's map of the Department of the Lower Seine, with some additions by Mr. De la Beche: thence to Cherbourg, from the maps annexed to the papers of M. Desnoyers and M. Constant Prevost, in the *Annales des Sciences Naturelles*, tome iv. 1825; and of the former, in the *Mémoires de la Société d'Histoire Naturelle de Paris*, tome ii. 1825.

The depths of water in the English Channel are taken from the Admiralty Chart. The lines under the figures were intended to represent the form of the bottom; but the depths are so enormously exaggerated, that without explanation they would convey a very erroneous impression. Mr. De la Beche's section of the channel between Portland and Cape La Hogue *, on the true relative scale of depths and horizontal distance, and more than five times as long as in this map, is scarcely different from an uniform line ruled with a common pen.

* "Sections and Views," &c. 4to, 1830. Plate II. fig. 2.

EXPLANATION OF THE PLATES.

Plate X. a.

Contains a series of sections, at right angles to the range of the chalk, on the lines marked in the map, Pl. IX., Nos. 1. to 25. The series begins on the coast north of Folkstone, and follows the outcrop of the chalk, round the Weald denudation of Kent and Surrey, &c.; thence along the coast, to Devonshire; and in the interior, from the Blackdown Hills to Norfolk. These sections are all drawn to the scale of the Ordnance maps, one inch to a mile. The heights are of necessity much exaggerated; but additional lines are given below Nos. 6. and 7. in the true proportion of height and distance.

No. 1. Section from *Folkstone Hill* to *Copt Point*, Kent: p. 104.—(See the Map, Pl. VII. fig. 1.; and Sectional Sketch; Pl. X. b. fig. 1.).

No. 2. Through *Tilburstow Hill* and *Godstone*, Surrey: p. 137.—(See the Map, Pl. VII. fig. 2.)

No. 3. Through *Nutfield* and *Merstham*, Surrey: p. 137—141.—(See the Map, Pl. VII. fig. 2.)

No. 4. From *Hindhead*, Surrey, through *Tucksbury Hill*, near Farnham: p. 144—149.

No. 5. Section across the Wealds, from the *South Downs* at *Duncton-Beacon*, through Floxham Park, Plaistow, and Aldfold, to the *North Downs* at *Netley Heath*; principally from Mr. Martin's MSS.: p. 155—160.

No. 6. The *Coast of Sussex and Kent*, from *Beachy Head* to *Folkstone Hill*;—part of which is given in greater detail in Pl. X. b. fig. 3. The lower line of this figure represents the cliffs on the true relative scale of height and horizontal extent: p. 161—164.

No. 7. Part of the *South Coast* of the *Isle of Wight*; from *Afton-Down* to *Rocken-End*, and from *Dunnose* to *Bembridge Down*:—(See also the transverse Section Pl. X. b. fig. 4.). In the lower line of this figure, the heights are in the true proportion to the horizontal distances.—p. 182—202.

No. 8. From *Durlstone Head*, through *Swanage*, to *Ballard Down*, *Dorsetshire*: p. 206—215.

No. 9. From *Broadbench*, in *Kimmeridge Bay*, Isle of Purbeck, to the Chalk-hills: p. 206—215.—(See Pl. X. b. figs. 5. and 6.).

No. 10. Section at *Lulworth Cove*, Dorsetshire: p. 215—216.—(See Pl. X. b. fig. 7.)

No. 10′. Section at *Man of War Cove*, west of Lulworth, Dorsetshire: p. 215—217.—(See Pl. X. b. fig. 8.)

No. 11. Coast near *Bere*, Devonshire: p. 234.—(See Pl. X. b. fig. 9.).

No. 12. *Blackdown Hill*, Devonshire: p. 238.

No. 13. Sections of the *Vale of Wardour*, in South Wiltshire: p. 245—255.—(See the Map, Pl. VII. fig. 3.).

—— on the anticlinal line, A. B.

—— on the transverse line, C. D.

—— on the transverse line, E. F.

—— on the transverse line, G. H.

No. 14. *Vale of Warminster*, South Wilts: p. 257.

No. 15. *Poulshot-Green* to *Etchilhampton Down*, North Wilts; drawn by Mr. Lonsdale: p. 261, 262.

No. 16. *Sandridge Hill* to *Beacon-Down Hill*, North Wilts; Mr. Lonsdale: p. 262—266.

[The dotted red lines adjacent to Nos. 15. and 16. in the map Pl. IX. denote the course of the Sections connected with Mr. Lonsdale's Paper in the Geol. Trans., 2nd Series, Vol. iii.; Pl. 32, figs. 1, 4, and 6.]

No. 17. *Swindon* to *Liddington Castle Hill*, North Wilts: p. 264—266.

No. 18. *Oxford*, through *Shotover Hill*, and *Great Hazeley*, to the chalk range, south-west of Stokenchurch Hill: p. 270—274.

The flap, No. 18′., gives the section, on a line nearly parallel to No. 18., along the main road from Oxford to London, through *Wheatley* and *Tetsworth*: p. 271—279.—(See the transverse section Pl. X. b. fig. 10.)

No. 19. From *Blackthorn-Hill*, in Oxfordshire, through *Muswell-Hill*, *Brill*, and *Thame*, to the chalk near Bledlow ridge: p. 270—279.

No. 20. From the north-west of *Whitchurch*, through *Aylesbury*, Bucks, to *Wendover Hill*, Berkshire: p. 270—284.—(See the transverse section, Pl. X. b. fig. 11.)

No. 21. Through *Woburn*, *Hockliffe*, and *Dunstable*, Bedfordshire: p. 270—293.

The flap, No. 21′., is the Section from *Fenny Stratford*, through *Little Brick-Hill*, to *Hockliffe*: p. 270—293.

No. 22. From *Caxton Gibbet*, Huntingdonshire, through *Cambridge*, to *Balsham*: p. 305—308.

No. 23. *Haddenham*, through *Denny Abbey*, to *Bottisham*, Cambridgeshire: p. 305.

No. 24. Through *Upware* on the Cam, to *Swaffham Prior*, Cambridgeshire: p. 305.

No. 25. Through *Lynn*, to *Swaffham*, West Norfolk; by Mr. C. B. Rose: p. 310—312.

No. 26. *Hunstanton Cliff*, Norfolk: p. 310—313. (See Plate X. b. fig. 12, *a*. *b*. and *c*.)

Plate X. b.*

This Plate contains miscellaneous Views and Sections, on different scales, illustrating the country represented in some of the sections of Pl. X. a.

Fig. 1. A sketch of part of the *Coast near Folkstone*, not visible in the direct line from the sea: p. 106—108. Reduced from a drawing by the Rev. C. D. Glennie.—(See Plate X. a. No. 1.

Fig. 2. Section on the west of *Pulborough*, in Western Sussex, showing the subdivisions of the Lower Greensand: Mr. Martin's MSS.: p. 155.

Fig. 3. Enlarged Section, on the same scale of height and distance, of part of the coast near *Hastings* and *St. Leonard's*, Sussex: p. 164.—(See Pl. X. a. No. 6.).

Fig. 4. Transverse Section, from *Brook Point* to *Shalcomb Down*, Isle of Wight: p. 200.—(See Pl. X. a. No. 7.)

Fig. 5. Enlarged Section at *Emmet's Hill*, Isle of Purbeck: p. 211.—(See Pl. X. a. No. 8.)

Fig. 6. Ideal Section, from *St. Alban's* Head to *Worbarrow knob*, in the Isle of Purbeck: page 211, 212.—(See Pl. X. a. No. 9.)

* This Plate is subsidiary to Plate X. a.; but is placed before it in binding, that both may fold out and be consulted at the same time.

EXPLANATION OF THE PLATES.

Fig. 7. East side of *Lulworth Cove*, Dorsetshire: p. 216.—(See Pl. X. a. No. 10.)

Fig. 8. Plan of *Durdle*, and *Man-of-War Coves*, and Section of the latter: p. 215—217. (See Pl. X. a. No. 10′.)

Fig. 9. Enlarged Section of part of the coast of Devonshire, from *Seaton* to *Branscomb Mouth*: p. 234.—(See Plate X. a. N. 11.)

Fig. 10. Transverse Section through *Garsington* and *Wheatley*, in Oxfordshire: p. 273. —(See Pl. X. a. No. 18′.)

Fig. 11. Transverse Section through *Quainton* and *Whitchurch*, Bucks: p. 271.—(See Pl. X. a. No. 20.)

Fig. 12. *a. b.* and *c. Hunstanton Cliff*, Norfolk.

Fig. 12. *a.* Map of part of the north-west *Coast of Norfolk*; from the Ordnance Survey, and on the same scale,—one inch to the mile: p. 310—313.

Fig. 12. *b.* Enlarged *Section of Hunstanton Cliff*, by Mr. Murchison: p. 310.—(See Plate X. a. No. 26.)

Fig. 12. *c. View of Hunstanton Cliff*, from the point * of the preceding figure; from a sketch by the Rev. W. Whewell: p. 310.

Fig. 13. Abstract Section, representing the whole series of strata illustrated in Plates X. a. and X. b.: p. 318, &c.

Plates XI to XXIII.

These Plates contain figures of the new and more remarkable fossils, obtained from the tract described in Dr. Fitton's paper. The details are explained in Mr. Sowerby's descriptive notes; Appendix A.—p. 335—348.

Plate XI.†

FOSSILS OF THE UPPER GREEN-SAND AND GAULT.

CHALK MARL.

Fig. 1. *Tornatella* elongata.

UPPER GREEN-SAND.

2. *Lucina*? globosa.
3. *Avicula* gryphæöides.

GAULT.

4. *Pentacrinites.*
5. *Pollicipes* lævis.
5*. ——— unguis.
6. *Pollicipes* radiatus. (Lower green-sand, p. 130.)
6*. ——— rigidus.
7. *Venus*? tenera.
7*. *Venericardia* tenuicosta.
8. *Nucula* bivirgata.
9. *Modiola* bella.
10. *Lima* semisulcata.
11. *Auricula* inflata.
12. *Natica* canaliculata.
13. *Solarium* ornatum.
14. *Solarium* conöideum.
15. *Pyrula* Smithii.
16. *Rostellaria* elongata.
17. ——— buccinoides.
18. ——— marginata.
19. ——— carinata.
20. *Ammonites* circularis.
21. ——— symmetricus.
22. ——— crenatus.
23. ——— *cristatus.*

Plate XII.

FOSSILS OF THE GAULT (*continued*).

Fig. 1, 2. *Hamites rotundus.*

Fig. 3. *Hamites* attenuatus.

Fig. 4. *Hamites* spiniger.

Plate XIII.

FOSSILS OF THE LOWER GREEN-SAND.

Fig. 1. *Echinus*? arenosus.
2. *Panopœa* rotundata.

Fig. 3. *Trigonia* spinosa (var.).

Fig. 4. *Diceras* Lonsdalii.

† In the following lists of names, the *new* species are in Roman characters; those previously figured, in Italics.

EXPLANATION OF THE PLATES.

Plate XIV.

FOSSILS OF THE LOWER GREEN-SAND, (*continued*).

Fig. 1. *Pholas* giganteus.
2. *Modiola* lineata.
3. *Avicula* pectinata.
4. *Ostrea* retusa.
5. *Anomia* radiata.
6. ——— lævigata.
7. *Anomia* convexa.
8. *Terebratula* Tamarindus.
9. ——— quadrata.
10. ——— Faba.
11. ——— elegans.
12. ——— convexa.
13. *Terebratula* parvirostris.
14. ——— prælonga.
15. *Lingula* truncata.
16. *Pleurotomaria* striata.
17. *Ammonites* furcatus.

Plate XV.

FOSSILS OF THE LOWER GREEN-SAND, (*continued*).

Scaphites Hillsii; the detail of the figures is explained at p. 339.

Plate XV. a.

FOSSILS OF THE GREEN-SAND OF BLACKDOWN.

Siphonia pyriformis; the figures are explained in detail at p. 340.

Plate XVI.

FOSSILS OF THE GREEN-SAND OF BLACKDOWN, (*continued*).

Fig. 1. *Pollicipes* lævis.
2. *Serpula* filiformis.
3. ——— Tuba.
4. ——— Vermes.
5. *Panopœa* ovalis.
6. *Mya* læviuscula.
7. *Amphidesma* tenuistriatum.
8. *Corbula* truncata.
9. *Mactra?* angulata.
10. *Petricola* nuciformis.
11. ——— canaliculata.
12. *Psammobia?* gracilis.
13. *Lucina* orbicularis.
14. ——— Pisum.
15. *Astarte* concinna.
16. ——— formosa.
17. ——— multistriata.
18. ——— impolita.
19. *Cyprina* cuneata.

Plate XVII.

FOSSILS OF THE GREEN-SAND OF BLACKDOWN, (*continued*).

Fig. 1. *Cyprina* rostrata.
2. *Cytherea* subrotunda †.
3. *Venus?* truncata.
4. ——— submersa.
5. ——— sublævis.
6. ——— immersa.
7. *Cucullæa* formosa.
8. *Arca* rotundata.
9. *Nucula* lineata.
10. ——— apiculata.
11. ——— obtusa.
12. *Trigonia* quadrata.
13. *Modiola* reversa.
14. *Mytilus* tridens.
15. *Mytilus* prælongus.
16. ——— inæquivalvis.
17. *Perna* rostrata.
18. *Avicula* anomala.
19. *Pecten* Millerii.
20. ——— compositus.
21. *Lima* subovalis.

Plate XVIII.

FOSSILS OF THE GREEN-SAND OF BLACKDOWN, (*continued*).

Fig. 1. *Pecten* Stutchburiensis.
2. *Terebratula* dilatata.
3. ——— megatrema.
4. *Dentalium* medium.
5. *Litorina* pungens.
6. *Natica* canaliculata.
7. ——— granosa.
8. ———? carinata.
9. *Tornatella* affinis.
10. *Vermetus* concavus.
11. *Scalaria* pulchra.
12. *Litorina* gracilis.
13. *Phasianella* pusilla.
14. ——— formosa.
15. ——— striata.
16. *Fusus* rigidus.
17. —— *quadratus*.
18. —— rusticus.
19. *Fusus* clathratus.
20. *Pyrula depressa*.
21. ——— Brightii.
22. *Rostellaria* retusa.
23. ——— macrostoma.
24. ——— *Parkinsonii*.
25. *Nassa* lineata.
26. —— costellata.
27. *Ammonites* triserialis.

Plate XIX.

FOSSILS OF THE WEALDEN.

External forms of *Endogenites erosa*: the details are explained at p. 173—175.

† In the Table at p. 355, *Cytherea* subrotunda is erroneously referred to Plate XXII. fig. 2.

EXPLANATION OF THE PLATES.

Plate XX.

FOSSILS OF THE WEALDEN (*continued*).

Illustrates the internal structure of *Endogenites erosa*; the details are given at pp. 175, 176.

Plate XXI.

FOSSILS OF THE WEALDEN (*continued*).

Fig. 1. *Cypris* Valdensis.
2. —— tuberculata.
3. —— spinigera.
4. —— granulosa.
5. *Corbula* alata.
6. *Psammobia* tellinoïdes.
7. *Cyclas* parva.
8. —— subquadrata.
9. —— elongata.
10. —— *media*.
11. —— ——, (var.)
12. —— angulata.
13. *Cyclas* major.
14. *Unio* Mantellii.
15. —— subtruncatus.
16. —— Gualterii.
17. —— Martinii.
18. *Mytilus* Lyellii.

Plate XXII.

FOSSILS OF THE WEALDEN AND PORTLAND-STONE.

WEALDEN.

Fig. 1. *Exogyra* Bulla.
2. *Ostrea* distorta.
3. *Bulla* Mantelliana.
4. *Melanopsis*? tricarinata.
5. ———— attenuata.
6. *Paludina* Sussexiensis.
7. *Neritina Fittonii*.
8. *Tornatella* Popii.
9. A *Cone* from the Isle of Purbeck; (p. 349.)
10. A *Cone* from Sussex; (p. 349.)
11. An unknown body from Quainton; (p. 349.)

PORTLAND-STONE.

12. *Lucina* Portlandica.
13. *Cytherea* rugosa.
14. *Trigonia incurva*.

Plate XXIII.

FOSSILS OF THE PORTLAND-STONE, KIMMERIDGE-CLAY, AND OXFORD-OOLITE.

PORTLAND-STONE (*continued*).

Fig. 1. *Ostrea* falcata.
2. *Nerita* angulata.
3. *Natica* elegans.
4. *Buccinum* naticoïde.
5. ———— angulatum.
6. *Terebra* Portlandica.

KIMMERIDGE & WEYMOUTH STRATA.

7. *Serpula* variabilis.
8. ———— triserrata.
9. *Panopœa* depressa.
10. *Exogyra Virgula*.
11. *Trigonellites latus*.

OXFORD-OOLITE.

12. *Nerinea* Goodhallii.

Plate XXIV.

Illustrates Mr. Bell's Memoir "On a new fossil species of *Chelydra*": p. 379—381.

Plate XXV.

Illustrates Professor Sedgwick's memoir "On the new red sandstone series, in the basin "of the Eden and north-western coasts of Cumberland": p. 383—407.

Fig. 1. Section on the coast of Cumberland, between *Parton* and *St. Bee's Head*: p. 391—393.

Fig. 2. Section from the mountains east of *Mollerstang*, to the overlying conglomerates in the valley of the *Eden* above *Kirkby Stephen*; showing the great fault and the breaks in the carboniferous series: p. 383—390.

Fig. 3. Section from the greywacké mountains of *Westmorland*, through *Orton Scar* and *Burrels*, to the *Eden*; p. 386.

Fig. 4. Section exposed in *Ben How* quarry, between *St. Bees* and *Whitehaven*: p. 388.

Fig. 5. Section from the mountains of *Copeland Forest*, through *Cold Fell*, to the sea north of the *river Calder*: p. 389—391.

EXPLANATION OF THE PLATES.

Fig. 6. Section from *Corney Fell* to the sea-coast west of *Bootle*: p. 389—399.

Fig. 7. Section from the Mountain Limestone Hills at *Low Furnace*, to *Salt-Coats* opposite the *Island of Barrow*: p. 389.

Plates XXVI. to XXVIII.

Illustrate Col. Sykes's memoirs "On a portion of the Dukhun in the East Indies": p. 409—432.

Plate XXVI.

Map of the *Dukhun.*

Plate XXVII.

Panoramic Sketches.

No. 1. is a distant *view of the mountains*, on which are situated the celebrated *hill forts of Jewdun*, &c. It is taken from the hill N. of the town of *Goreh*: p. 432.

No. 2. A view of the hills, to the North and East, as seen from Lakungaon in the flat broad valley of *Jooneir* (Sewneir).

No. 2*. is a continuation of the view *No.* 2. from the North round to the West.

No. 3. A sketch of the *hills to the North and East*, as seen from the summit of the armoury, in the fort of *Ahmednuggur*.

No. 4. A sketch of the northern flank of *the Plateau* on which the city of *Ahmednuggur* stands; as seen from *Wamooree*, in the plain of the Godavery river.

Plate XXVIII.

Fig. 1. Elevation and declination of the *country above the Ghàts*, between 73° 35′ and 74° 49′ East Longitude, and 18° 50′ and 19° 10′ 3″ North Latitude: p. 411—418, 432.

Fig. 2†. Elevation and declination of the *country above the Ghàts*, between 17° 35′ and 74° 49′ East Longitude, and 18° 28′ and 18° 50′ North Latitude: p. 424—432.

These Sections are fully explained at p. 432.

Plate XXIX.

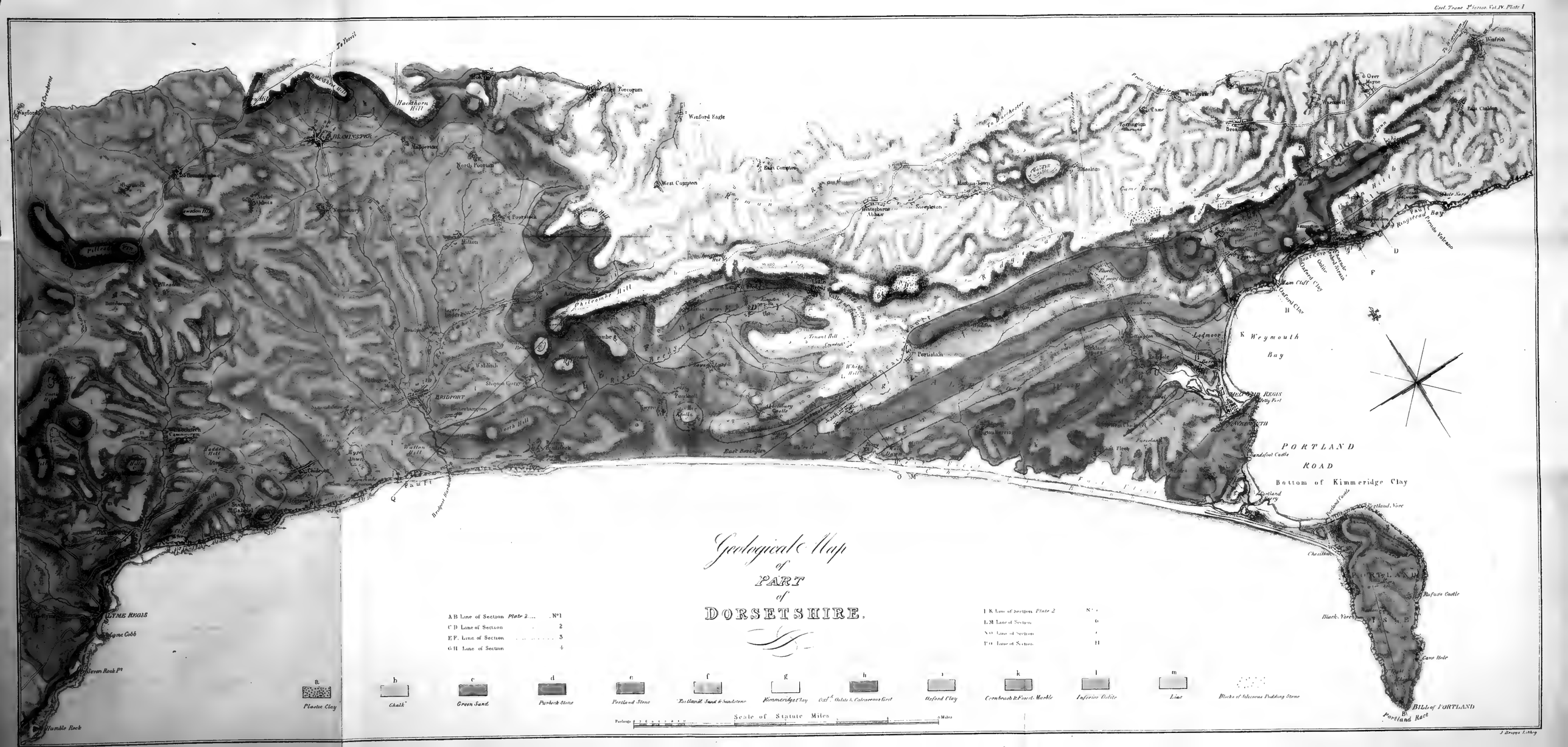
Illustrates Mr. Horner's paper "On the Environs of Bonn"; p. 433—481.

The principal division of the plate is a Map of the *Environs of Bonn*; described at p. 434.

Beneath is a panoramic view of the *Hills on the East of the Rhine*, as seen from the Coblentz Gate of Bonn.

The remaining division of the Plate represents the *vertebræ of a Fish*, probably, of the genus *Lamna*, found in the loess near Basle; the smaller figures are of the natural size; pp. 476, 480.

† In the engraving of fig. 2., the names *Moteh* and *Mota* are confounded. *Mota* is the name of the River, *Moteh* that of the Town.



J. Basire Lithog.

Purbeck Stone.
Fault.
Upway
Buckland Ripers.
E. Chickerel.
Wyke Regis.
Portland Ferry.
Chesil Bank 2 Miles.
Chalk
Portland Stone.
Portland Sand
Kimmeridge Clay
Oxford Oolite & Calc Grit
Oxford Clay.
Cornbrash
Forest Marble.
Oxford Clay.
Oxford Oolite & Calc. Grit.
Clay.
Kimmeridge
Clay.
Kimmeridge
Sand.
Portland
Stone.
Portland
Fig. 2. (C.D.)
N
S
Moignesdown Farm
Moignesdown Circus
Upton Valley.
Upton Hill.
Fault
Lime Kiln.
Ringstead Bay.
Fig. 3. (E.F.)
N
S
Poxwell Hill.
Fault.
Poxwell Circus.
Upton Farm.
Upton Hill.
Fault.
Osmington Mills
Signal.
Fig. 4. (G.H.)
N
S
Fault.
Sutton Pointz Valley
Preston Hill.
Preston V.
Ham Cliff.
Sea.
Fig. 5. (I.K.)
N
S
b
Fault.
Sutton Pointz Valley
Preston Valley.
Jordon Hill.
Sea.
Fig. 6. (L.M.)
N
S
Abbotsbury Common.
Chalk
Green Sand.
Fault.
Abbotsbury.
Linton Hill.
Fig. 7. (N.O.)
N
S
Abbotsbury Castle.
Clay.
Fault.
Abbotsbury Valley.
Swanery.
Chesil Bank
Sea
Forest Marble.
Ox. Clay.
Fig. 8.
W
E
Jordon Hill
Oxford Oolite.
Calc. Grit.
Oxford Clay
Oolite
Clay
Grit
Ham Cliff.
Fault.
Oolite
Clay
Grit
Kim. Clay.
Oxford Clay.
Fig. 9.
W
E
Green Sand
Kim. Clay
Grit
Oolite
Clay
Oolite
Lower Grit.
Osmington Mills
Signal
Kim. Clay
Ringstead Bay.
Boat Cove
Cascade
Lower Grit.
Gray Marl.
Grit
Oolite
Upper Grit
Fig. 10.
W
E
White Nore
Kim. Clay
Green Sand.
Chalk.
Fig. 11.
Portland Stone
Fault
Ringstead Bay.
Kim. Clay.
Burning Cliff.
Fig. 12.
Fault.
Portland Stone
Portland Sand.
b
a
c
Chalk
Kimmeridge Clay
Green Sand.
Fig. 13.
Fault
Watton Hill West End.
Forest Marble
Inf. Oolite.
Gray Clay
Sea.
Lias.
Fig. 13. a.
Watton Hill East End
Gray Marl
Marlstone
Gray Marl
Compound Fault.
Fig. 14. (P.Q. of the Map.)
S.W
N.E
Bridport Harbour W. Cliff
Fault.
Forest Marble
Clay
Sea
Upper Lias Marl
Inferior Oolite.
Bridport Valley.
River.
Forest Marble.
Bothenhampton
Fault.
Gray Clay.
Shipton Beacon.
Green Sand.
Travellers Rest
Chalk
Askerswell.
Clay beneath Forest Marble
Inferior Oolite.
b
Chalk
c
Green Sand
d
Purbeck Stone.
e
Portland Stone.
f
Portland Sand & Sandstone.
g
Kimmeridge Clay.
h
Oxford Oolite & Calcareous Grit.
i
Oxford Clay.
k
Cornbrash & Forest Marble.
l
Inferior Oolite
m
Lias

Fig. 1.

General Section of the Strata in the Weymouth District.

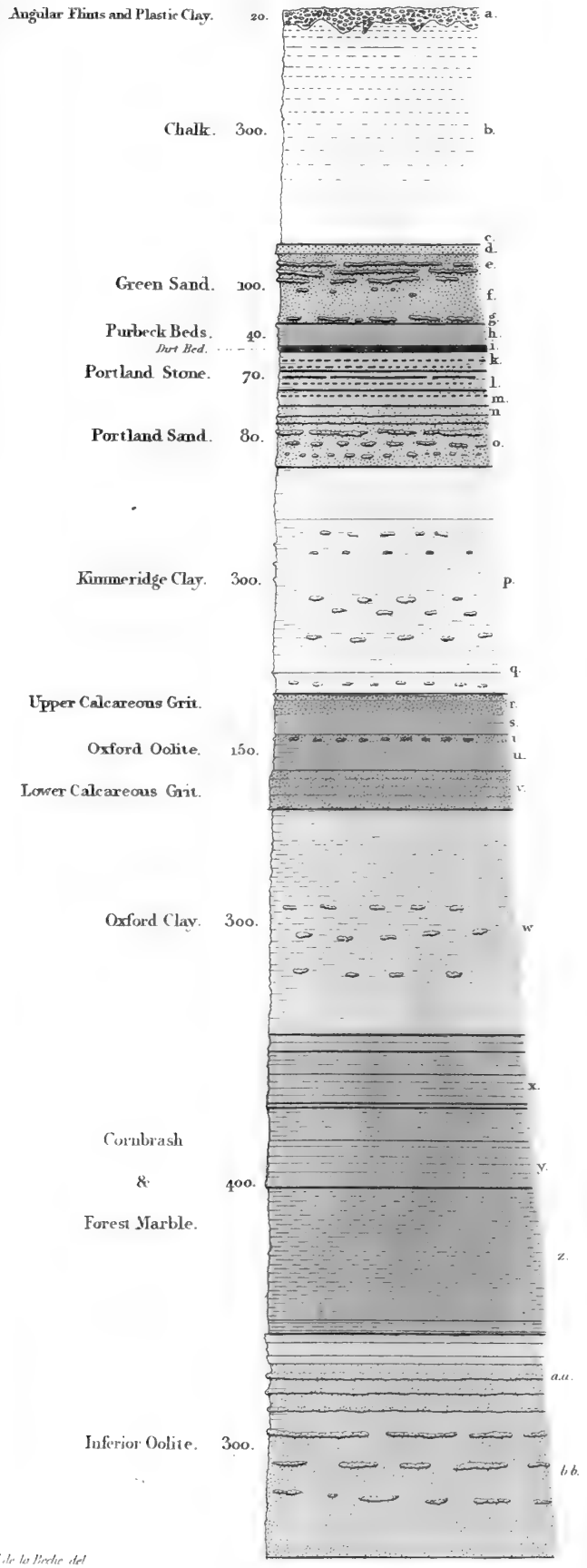


Fig. 2.

Section between Ringstead Bay & Osmington Mills.

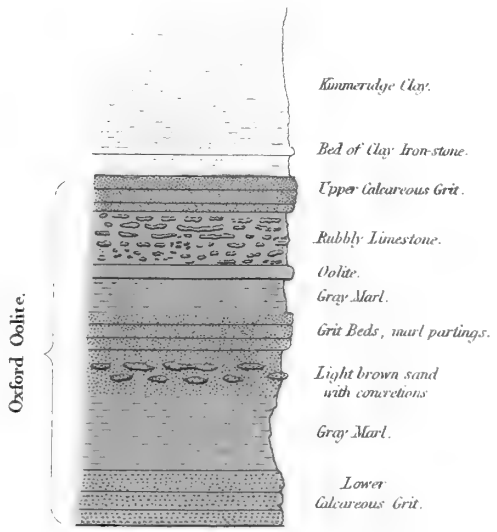
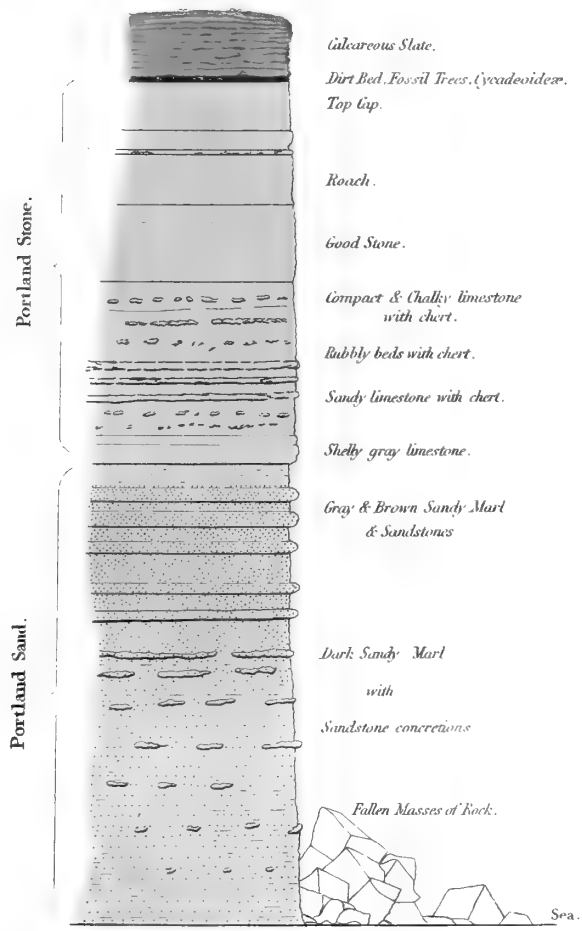
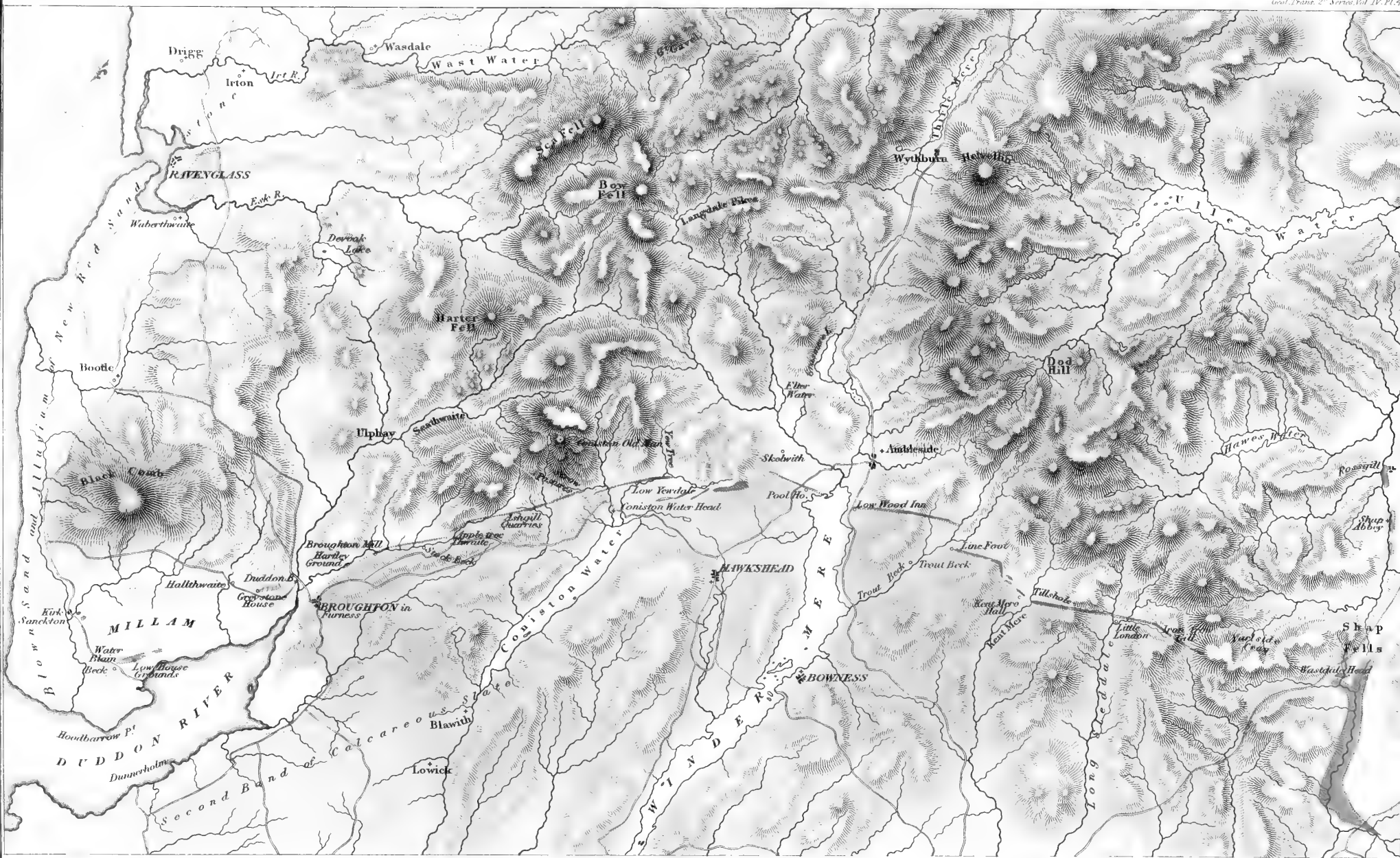


Fig. 3.

Section of the Cliff of Black Nore, W. side of Portland.



H T de la Beche del



Granite | Old slate of Black Comb. | Green slate and Porphyry. | Bands of Limestone. | Greywacke. | Old red Sandstone. | Mountain Limestone.

Fig. 1. (p. 59)

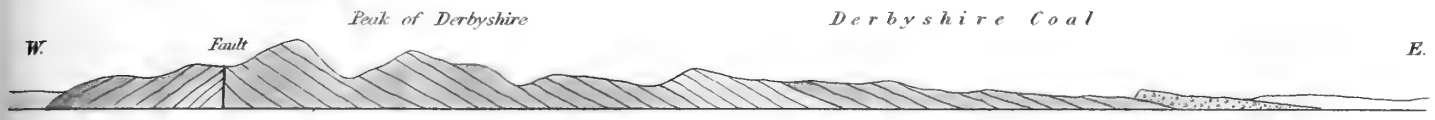


Fig. 2. (p. 60)

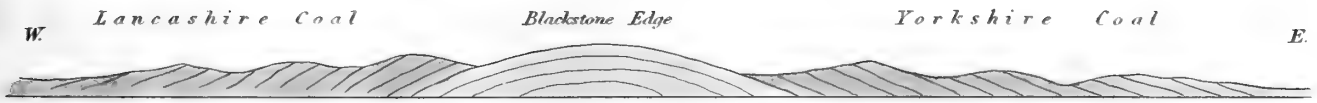


Fig. 3. (p.p. 60. 61)

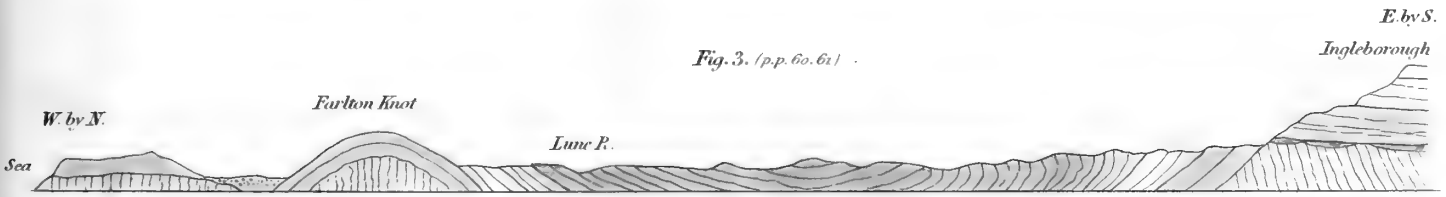


Fig. 4. (p. 61)

Fig. 5. (p. 61)

Fig. 6. (p. 62)

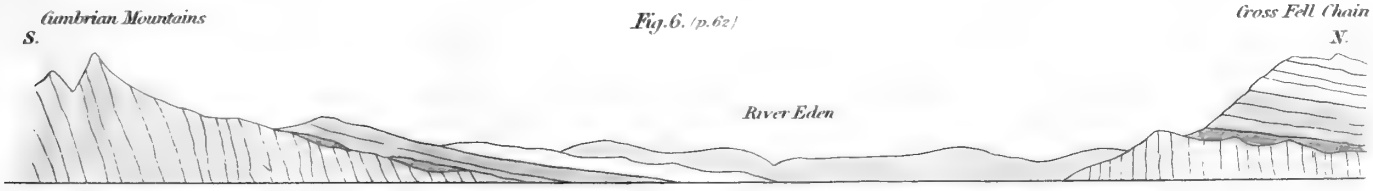


Fig. 7. (p.p. 61. 63)

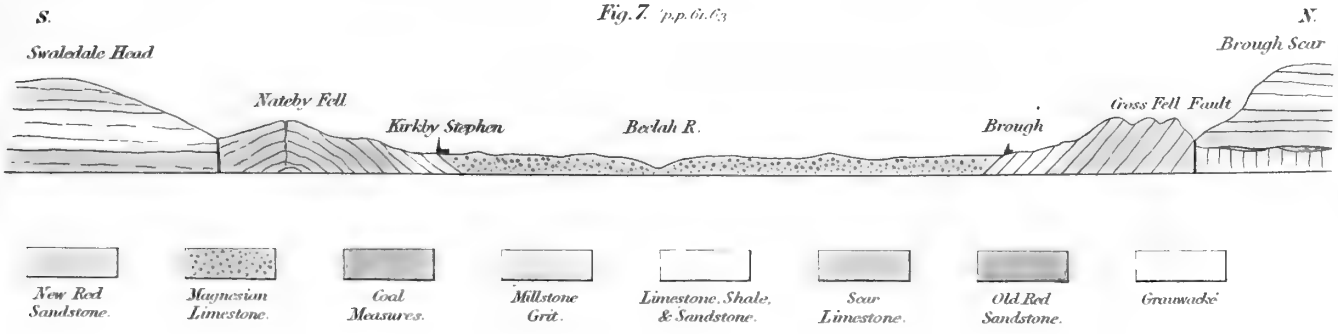


Fig. 1. GENERAL SECTION OF THE CARBONIFEROUS LIMESTONE SERIES & MILLSTONE GRIT.

(See p. 70.)

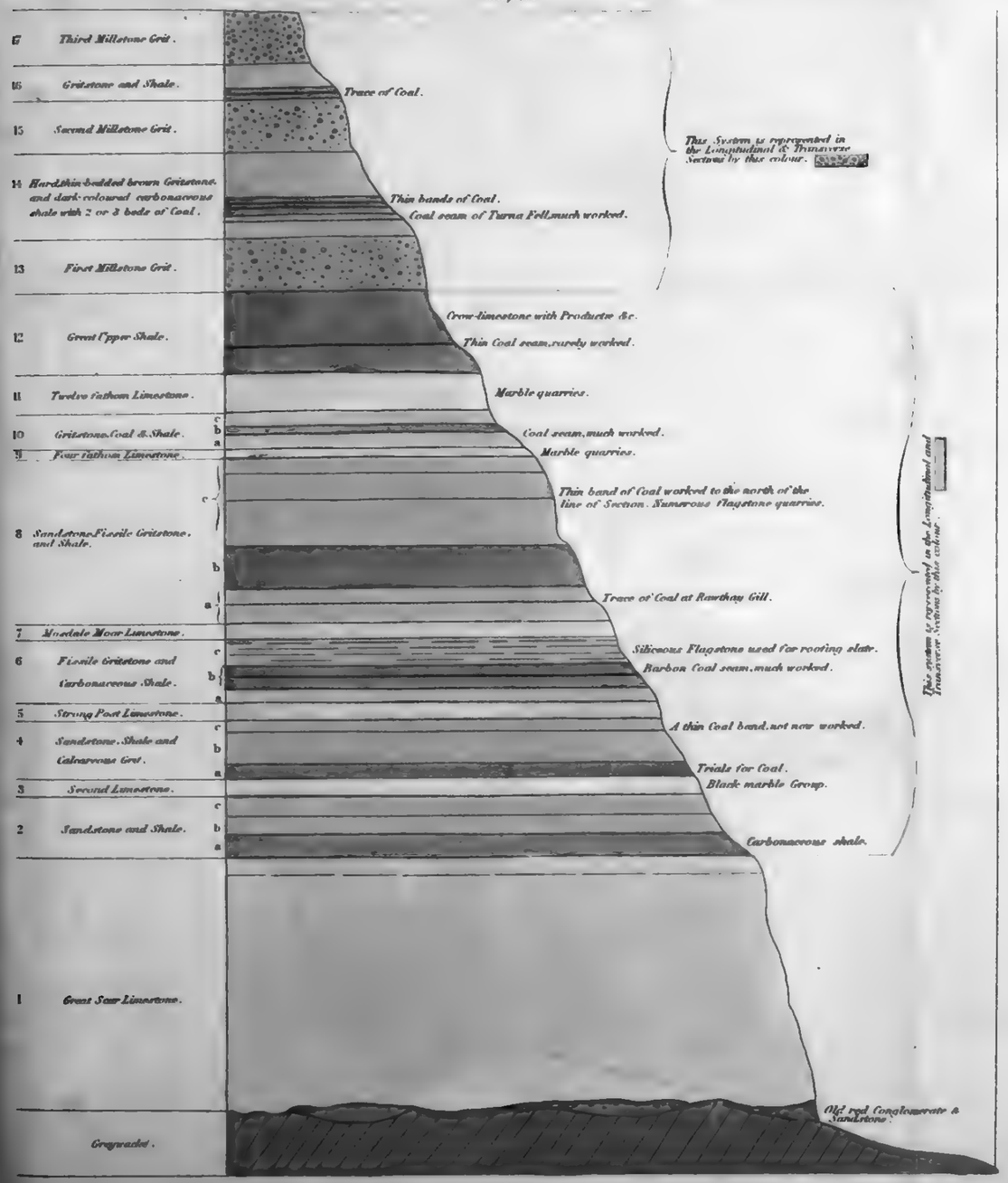


Fig. 2. LONGITUDINAL SECTION T

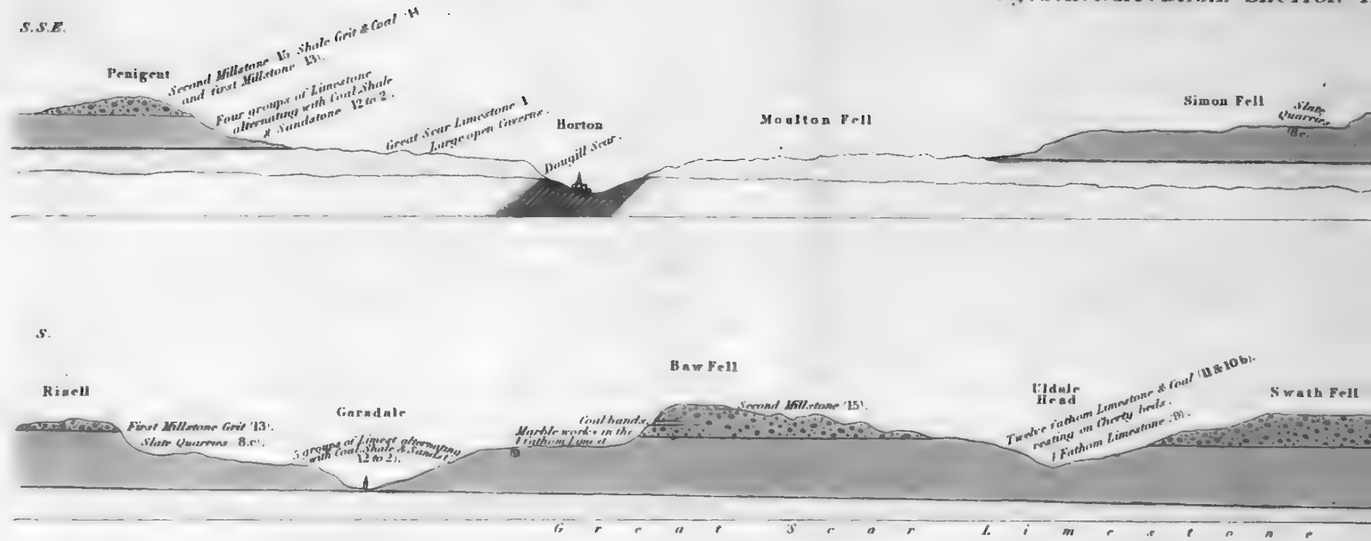
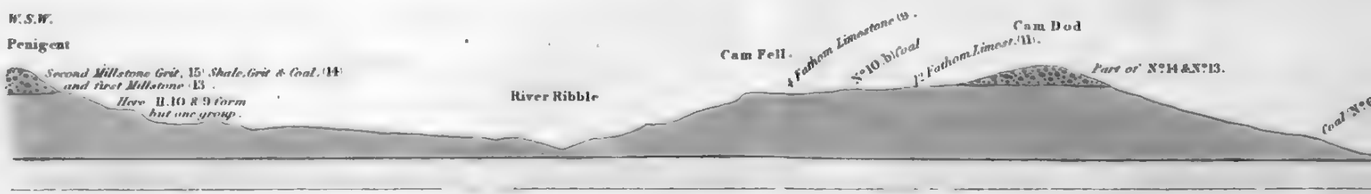


Fig. 3. LONGITUDINAL SECTION FROM THE TOP OF PENIGENT TO THE TOP OF STAGS FELL NEAR



SERIES OF TRANSVERSE

Fig. 5. TRANSVERSE SECTION. (See p. 94.

Fig. 7. TRANSVERSE SECTION. (see p. 95.)

NGITUDINAL SECTION THROUGH THE CARBONIFEROUS CHAIN FROM PENIGENT TO THE PLAINS OF THE EDEN NEAR KIRKBY STEPHEN. See p.84

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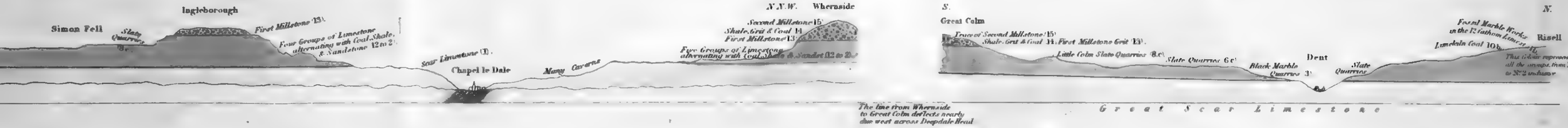


Fig. 2. CONTINUED.

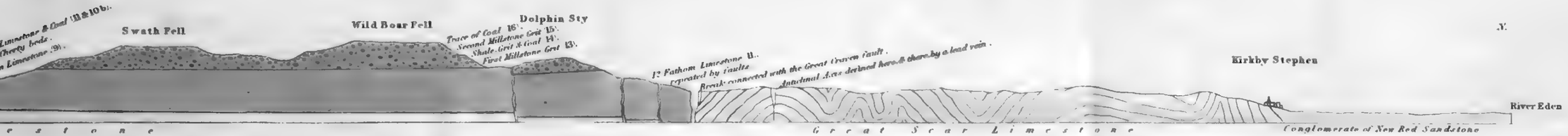
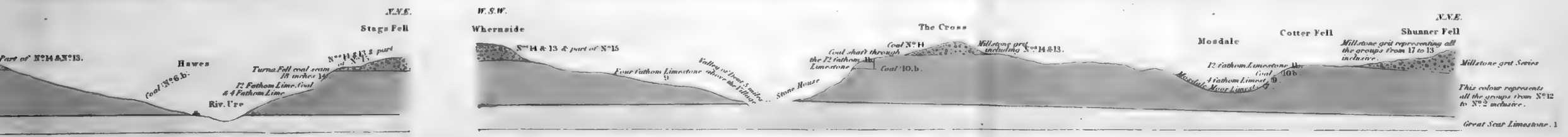


Fig. 4. LONGITUDINAL SECTION FROM THE TOP OF WHERNSIDE TO THE TOP OF SHUNNER FELL AT SWALEDALE HEAD. (See p.92.)



ERIES OF TRANSVERSE SECTIONS CONNECTING THE LONGITUDINAL SECTIONS WITH THE GREYWACKE CHAINS OF WESTMORLAND.

Fig. 6. TRANSVERSE SECTION. (See p.95.)

Fig. 8. TRANSVERSE SECTION. (See p.96.)

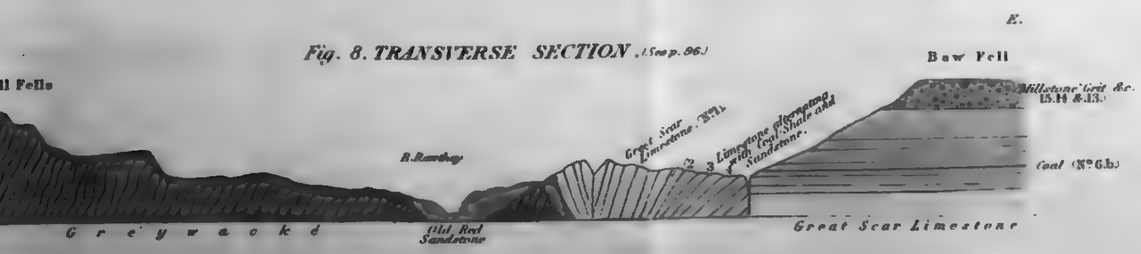


Fig. 9. TRANSVERSE SECTION. (See p.97.)

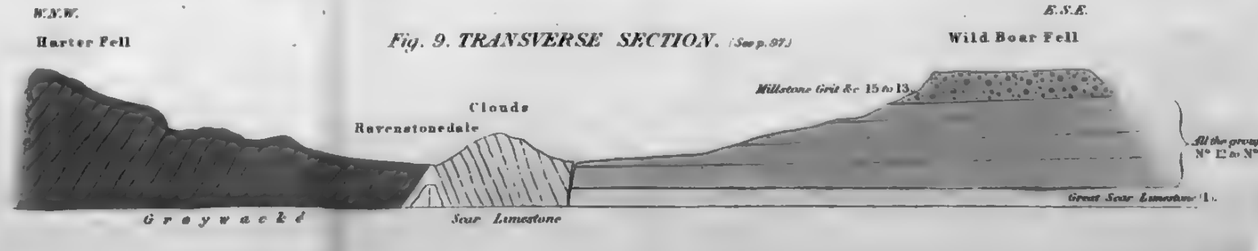


Fig 1

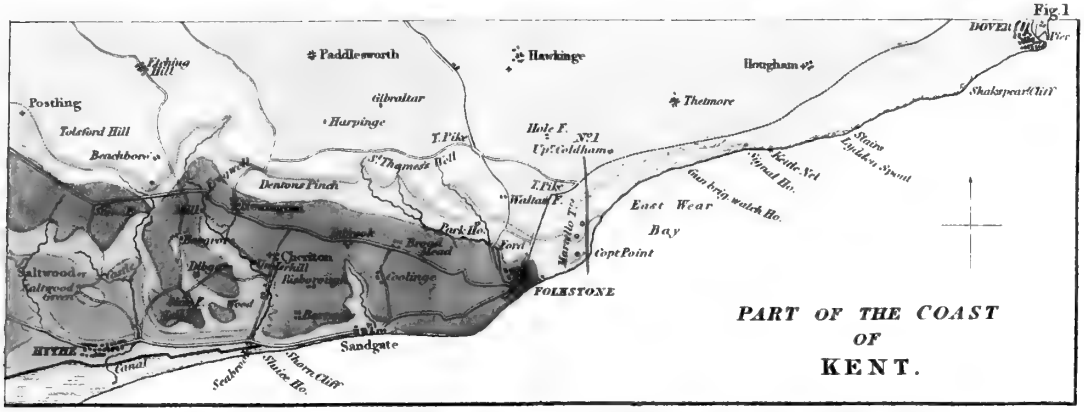


Fig 2

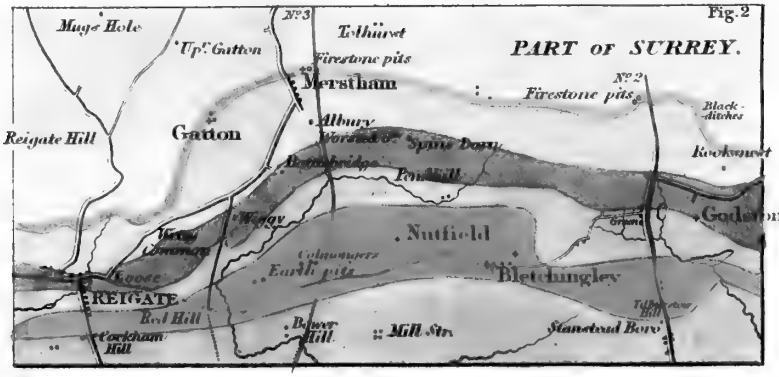
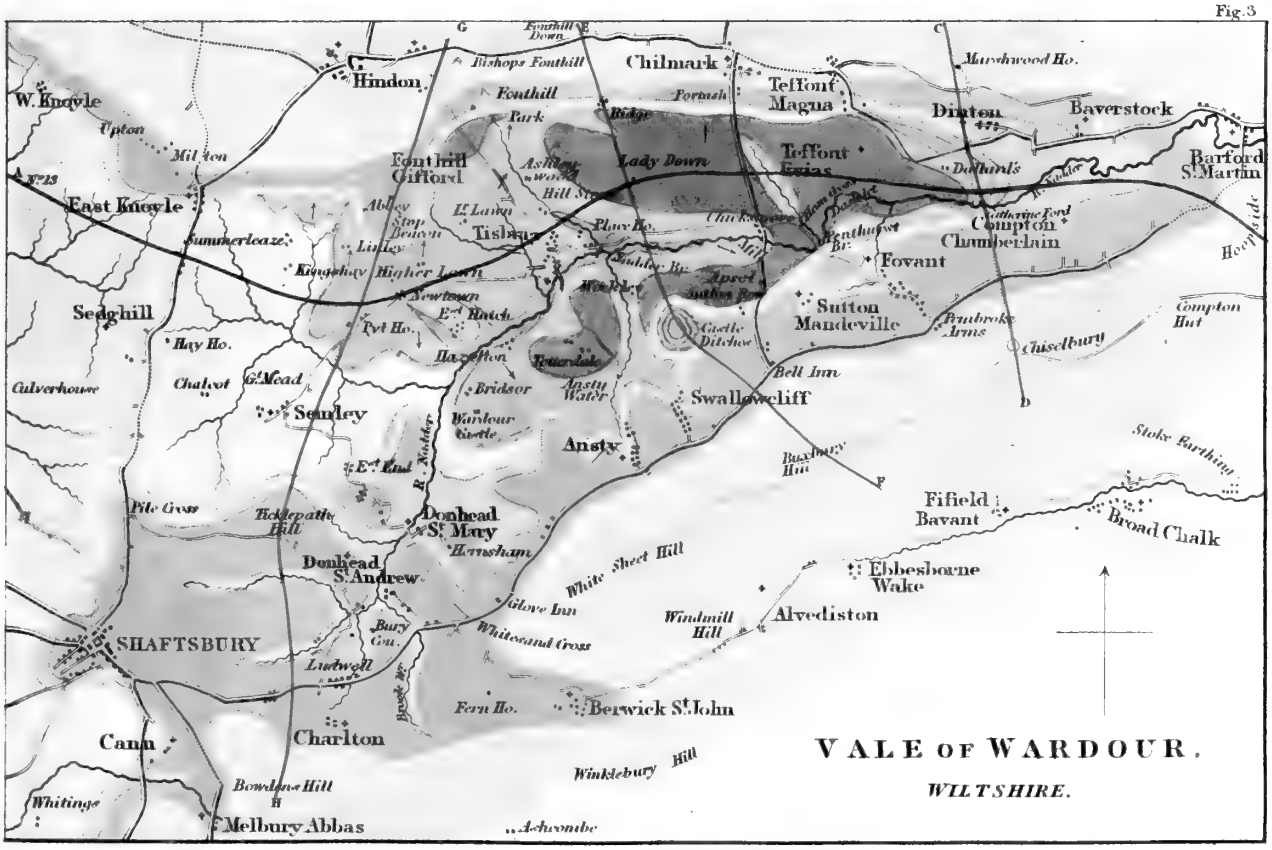


Fig 3



Chalk
Upper Greensand
Gault
Lower Greensand Fig. 1 & 2
Lower Greensand Fig. 3
Weald Clay Fig 1 & 2.
Hastings Sand Fig 3
Purbeck Strata
Stone } Portland
Sand }
Kimmeridge Clay & inferior beds
Lines of Section
Anticlinal line Fig 3. A.B.

Scale
1 ½ 0 1 2 3 4 Miles

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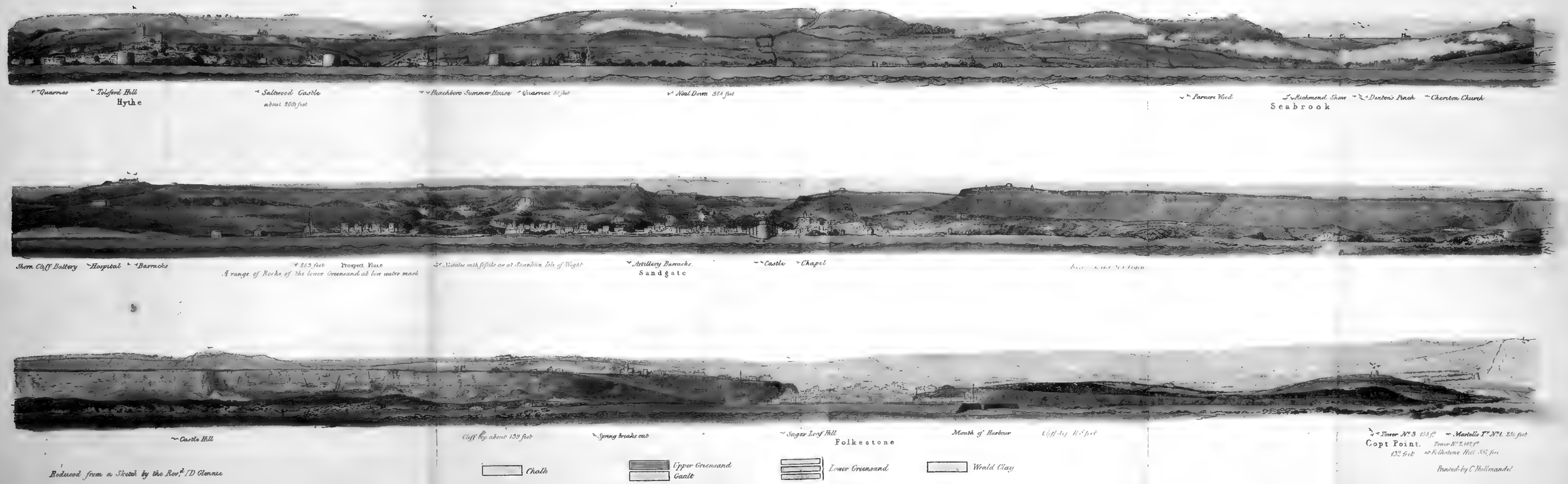
Sketch of Part of the Coast of Kent, from Hythe to Folkstone Hill.



Reduced from a Sketch by the Revd. I D Glennie

Printed by C Hullmandel

The Heights are taken from the mean level of the Sea

MAP
of part of the
SOUTH EAST OF ENGLAND,
and of the
OPPOSITE COAST OF FRANCE.

a Beds above the Chalk — Clay, Bagshot Sands, London Clay, Plastic Clay
b Chalk.
c Greensand — Upper Greensand, Gault, Lower Greensand (c', c'', c''')
d Weald Clay
e Hastings Sand. — Wealden
f Purbeck Strata.
g Portland Stone & Sand.
h Kimmeridge & Weymouth beds.
i Oxford Oolite & beds beneath.

Lines of Section. Nos 1 to 26.

Anticlinal Lines.

The Depths of the Sea, at low water, are expressed in fathoms.

Scale of English Miles.

Scale of Metres

THE WASH
BEDFORD LEVEL
LONDON
HOUSE OF THE THAMES
SEVERN R.
SALISBURY PLAIN
ISLE OF WIGHT
ROMNEY MARSH
STRAIT OF DOVER
ENGLISH CHANNEL
Oolitic Series
Oxford Clay
Weald Clay
Gault
Upper Greensand
Lower Greensand
Chalk
Kimmeridge Clay
Portland Stone
Purbeck Strata
Hastings Sand
Wealden
Coralline Oolite
Forest Marble
Great Oolite
Fuller's Earth
Inferior Oolite
Lias
Valley of the Paris Basin

COAST ON THE WEST OF HASTINGS, SUSSEX. p.164.

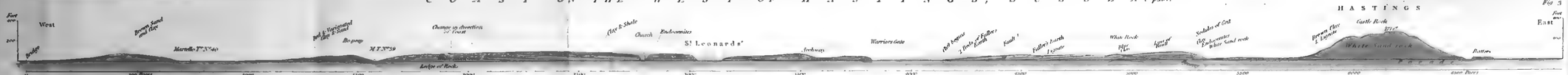


Fig 3

COPT POINT, near Folkstone, from the East ...p.206.

Fig 1.

West of PULBOROUGH, Sussex ...p.155.

Fig. 2.

Brook Point to Shalcomb Down. Isle of Wight ...p.200.

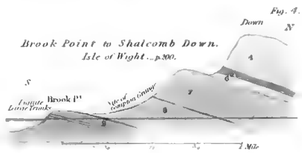


Fig. 4.

Durdle Cove.

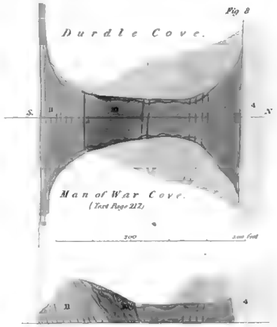


Fig 8

Emmet's Hill, I. of Purbeck. ...p.211.

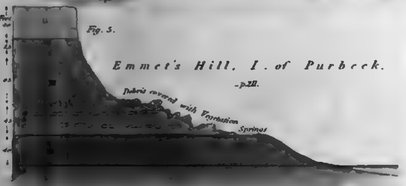


Fig. 5.

Ideal Section W. of St ALBANS HEAD, I. of Purbeck ...p.211.

Fig 6

East Side of LULWORTH COVE.

(see text page 216

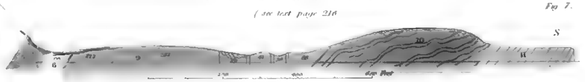


Fig 7.

Coast near BERE HEAD, Devonshire ...p.236.

Fig 9.

Transverse Section, through WHEATLEY Oxfordshire ...p.273.

Fig 10

Section, through QUAINTON and WHITCHURCH, Bucks...p.271.

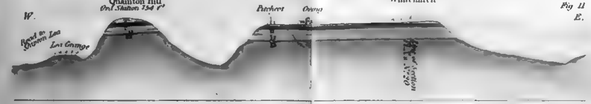
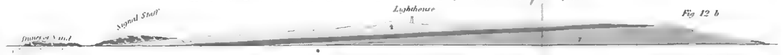
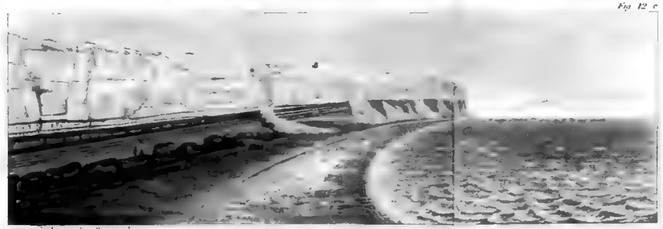


Fig 11

Part of the N W of Norfolk.

HUNSTANTON CLIFF, Norfolk ...p.230.

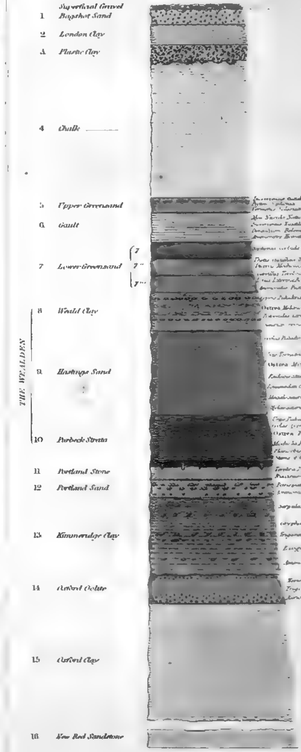


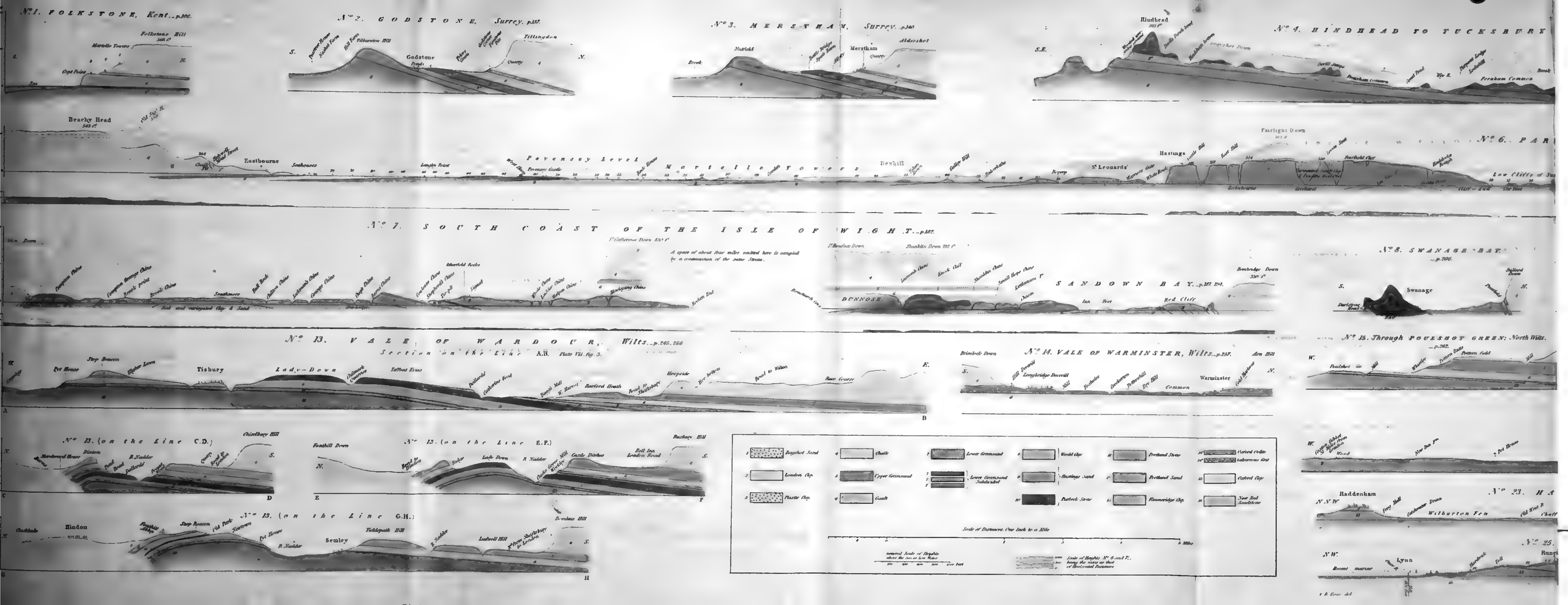


View from the point ... Fig 12 a. & b

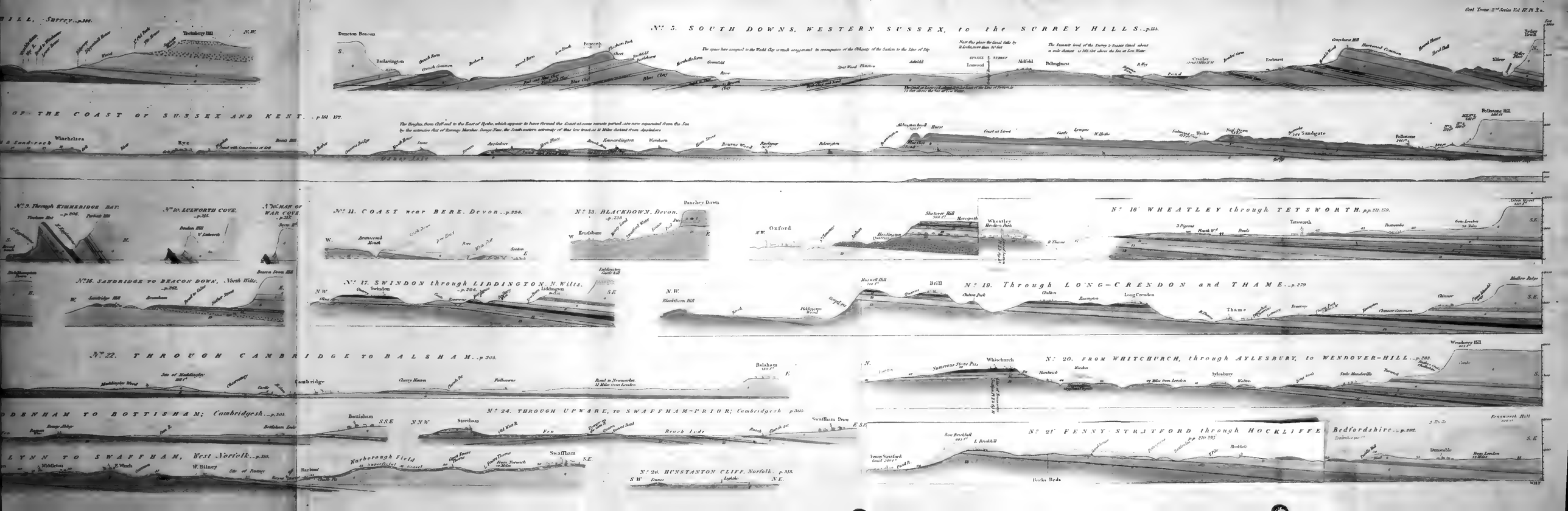
Fig 13

ABSTRACT SECTION of the Series of Strata represented in this Plate, and in Plate X a.





No. 1. FOLKSTONE, Kent. p.106.
Folkstone Hill
Martello Towers
Cape Point
No. 2. GODSTONE, Surrey. p.137.
Godstone
Tillingdon
Quarry
No. 3. MERSTHAM, Surrey. p.140
Merstham
Aldershot
Nutfield
Brook
No. 4. HINDHEAD TO TUCKSBURY
Hindhead
Fernham Common
Brook
Beachy Head
Eastbourne
Seahouses
Langley Point
Pevensey Level
Martello Towers
Bexhill
Gallery Hill
St. Leonards
Hastings
Fairlight Down
Low Cliffs of Sussex
No. 6. PAR
No. 7. SOUTH COAST OF THE ISLE OF WIGHT. p.182.
A space of about four miles omitted here is occupied by a continuation of the same Strata.
Red and variegated Clay & Sand
Rocken End
Bembridge Down
SANDOWN BAY. p.187. 194.
DUNNOSE
Red Cliff
Inn Fort
No. 8. SWANAGE BAY. p.206.
Swanage
Ballard Down
No. 13. VALE OF WARDOUR, Wilts. p.245. 256
Section on the Line A.B. Plate VII. fig. 3.
Tisbury
Lady-Down
Barford Heath
Hoopside
Road to Wilton
Race Course
No. 14. VALE OF WARMINSTER, Wilts. p.257.
Brimlock Down
Warminster
Common
No. 15. Through POULSHOT GREEN: North Wilts. p.262.
No. 13. (on the Line C.D.)
Chiselbury Hill
No. 13. (on the Line E.F.)
Fonthill Down
Lady Down
Castle Ditches
Bell Inn London Road
Rushbury Hill
No. 13. (on the Line G.H.)
Hindon
Semley
Tickdepath Hill
Ludwell Hill
Bowlens Hill
Bagshot Sand
London Clay
Plastic Clay
Chalk
Upper Greensand
Gault
Lower Greensand
Lower Greensand Subdivided
Weald Clay
Hastings Sand
Purbeck Stone
Portland Stone
Portland Sand
Kimmeridge Clay
Oxford Oolite
Calcareous Grit
Oxford Clay
New Red Sandstone
Scale of Distances, One Inch to a Mile
Miles
Scale of Heights above the Sea or Low Water
Scale of Heights No. 6 and 7, being the same as that of Horizontal Distances
No. 23. H A
Haddenham
Wilburton Fen
No. 25.
Lynn
Recent marine


HILL, Surrey ..p.304.
Nº 5. SOUTH DOWNS, WESTERN SUSSEX, to the SURREY HILLS. p.133.
OF THE COAST OF SUSSEX AND KENT. p.133 177.
Nº 9. Through STEMBRIDGE BAY. p.206.
Nº 10. LULWORTH COVE. p.215.
Nº 11. COAST near BERE, Devon. p.234.
Nº 13. BLACKDOWN, Devon. p.238.
Nº 16. WHEATLEY through TETSWORTH. pp.271 278.
Nº 16. SANDRIDGE TO BEACON DOWN, North Wilts. p.262.
Nº 17. SWINDON through LIDDINGTON, N. Wilts. p.264.
Nº 19. Through LONG-CRENDON and THAME. p.279
Nº 22. THROUGH CAMBRIDGE TO BALSHAM. p.305.
Nº 20. FROM WHITCHURCH, through AYLESBURY, to WENDOVER-HILL. p.283.
Nº 24. THROUGH UPWARE, to SWAFFHAM-PRIOR, Cambridgesh. p.305.
Nº 21. FENNY-STRATFORD through HOCKLIFFE, Bedfordshire. p.282.
Nº 26. HUNSTANTON CLIFF, Norfolk. p.313.
Dimeton Beacon
Barlavington
Petworth
Midhurst
Cuckfield
Lewes
Eastbourne
Hastings
Rye
Winchelsea
Beachy Head
Dungeness
Folkestone
Dover
Deal
Ramsgate
Margate
Sheerness
Gravesend
Blackheath
Greenwich
Croydon
Godstone
Reigate
Dorking
Guildford
Farnham
Alton
Petersfield
Chichester
Arundel
Shoreham
Brighton
Lewes
Battle
Tunbridge
Maidstone
Ashford
Canterbury
Sandwich
Thanet
Rochester
Chatham
Sittingbourne
Faversham
Whitstable
Herne Bay
Reculver
Isle of Sheppey
Isle of Thanet
Isle of Wight
Portsmouth
Southampton
Salisbury
Winchester
Basingstoke
Reading
Windsor
Staines
Kingston
Richmond
Hampton Court
Chertsey
Weybridge
Guildford
Godalming
Haslemere
Petersfield
Midhurst
Chichester
Arundel
Worthing
Brighton
Lewes
Hastings
Battle
Rye
Winchelsea
Romney Marsh

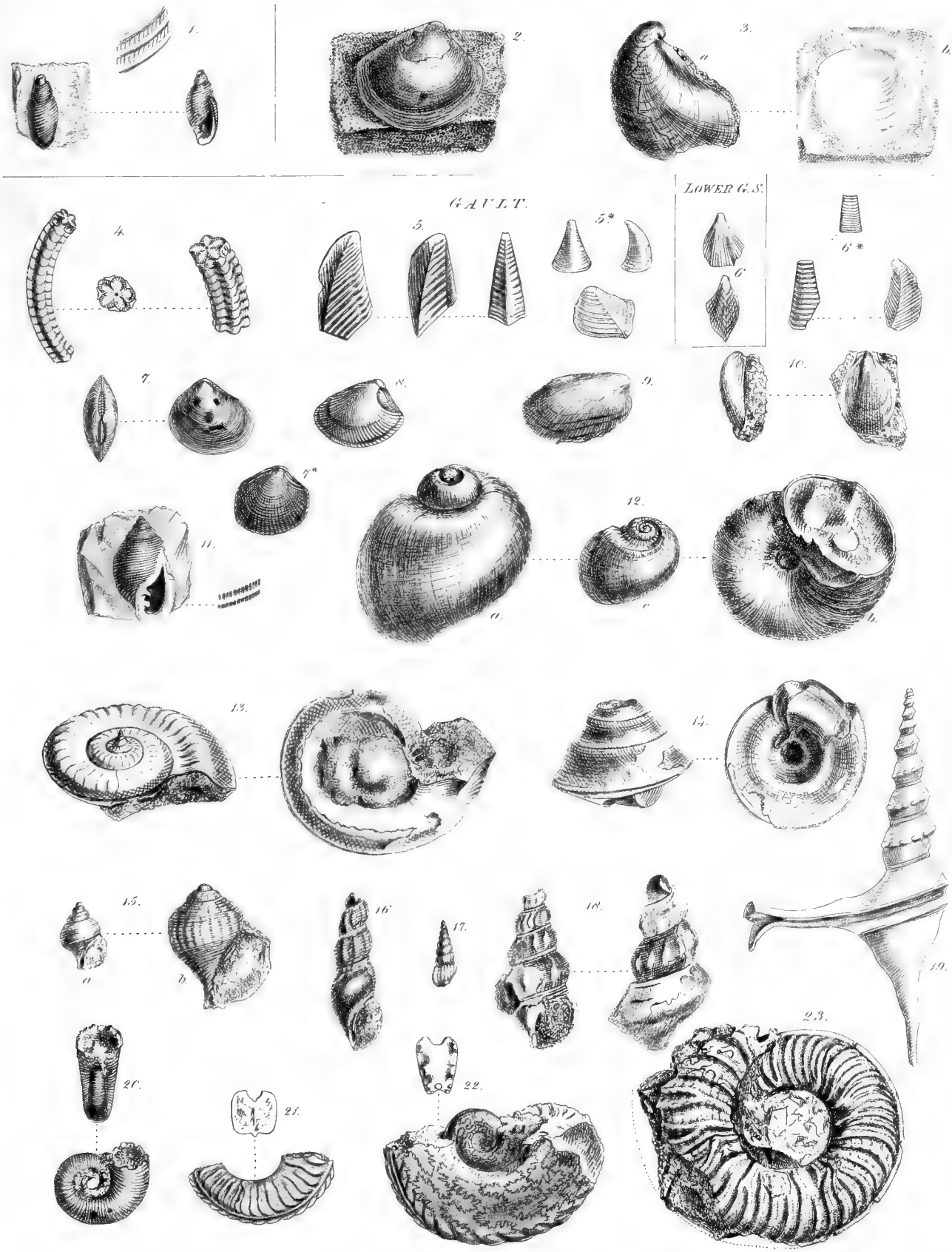
Pls. 11 – 23
Fitton's lobr. 103 – 388

CHALK-MARL.

UPPER GREENSAND.

GAULT.

LOWER G.S.



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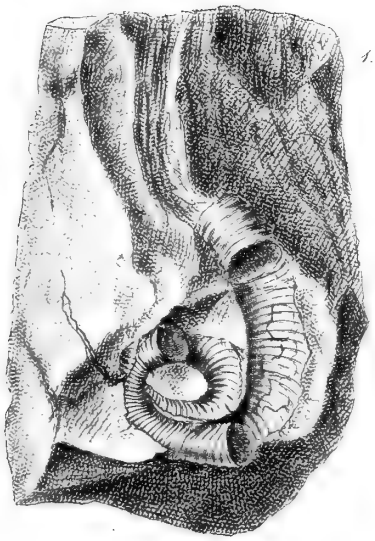
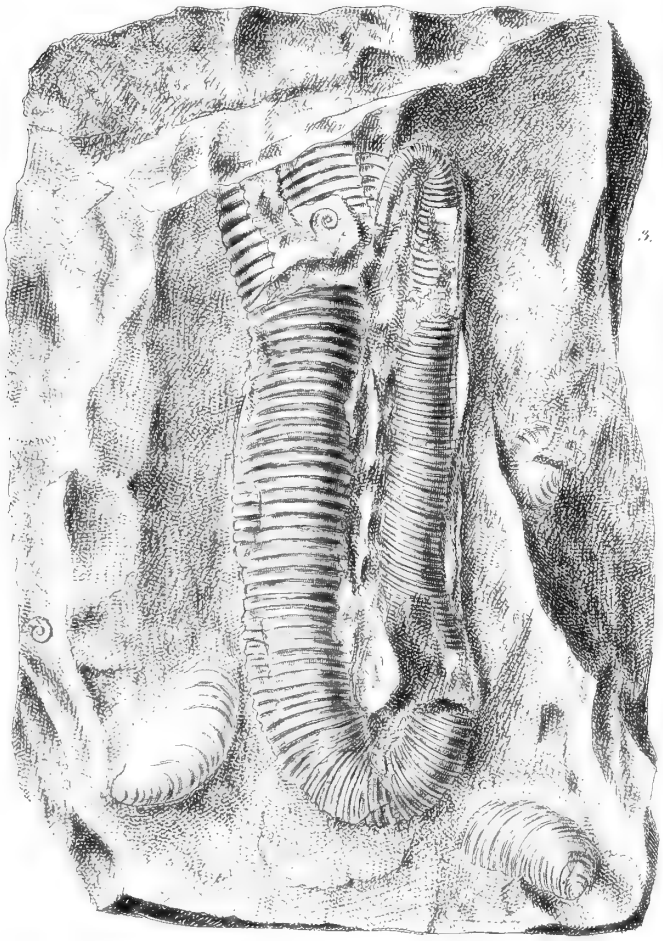
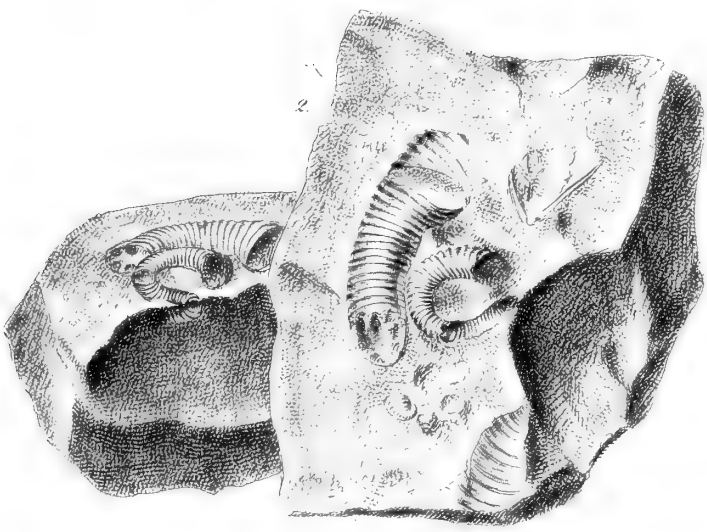
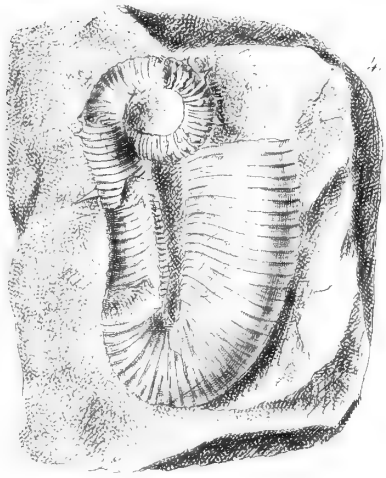
GAULT (continued)

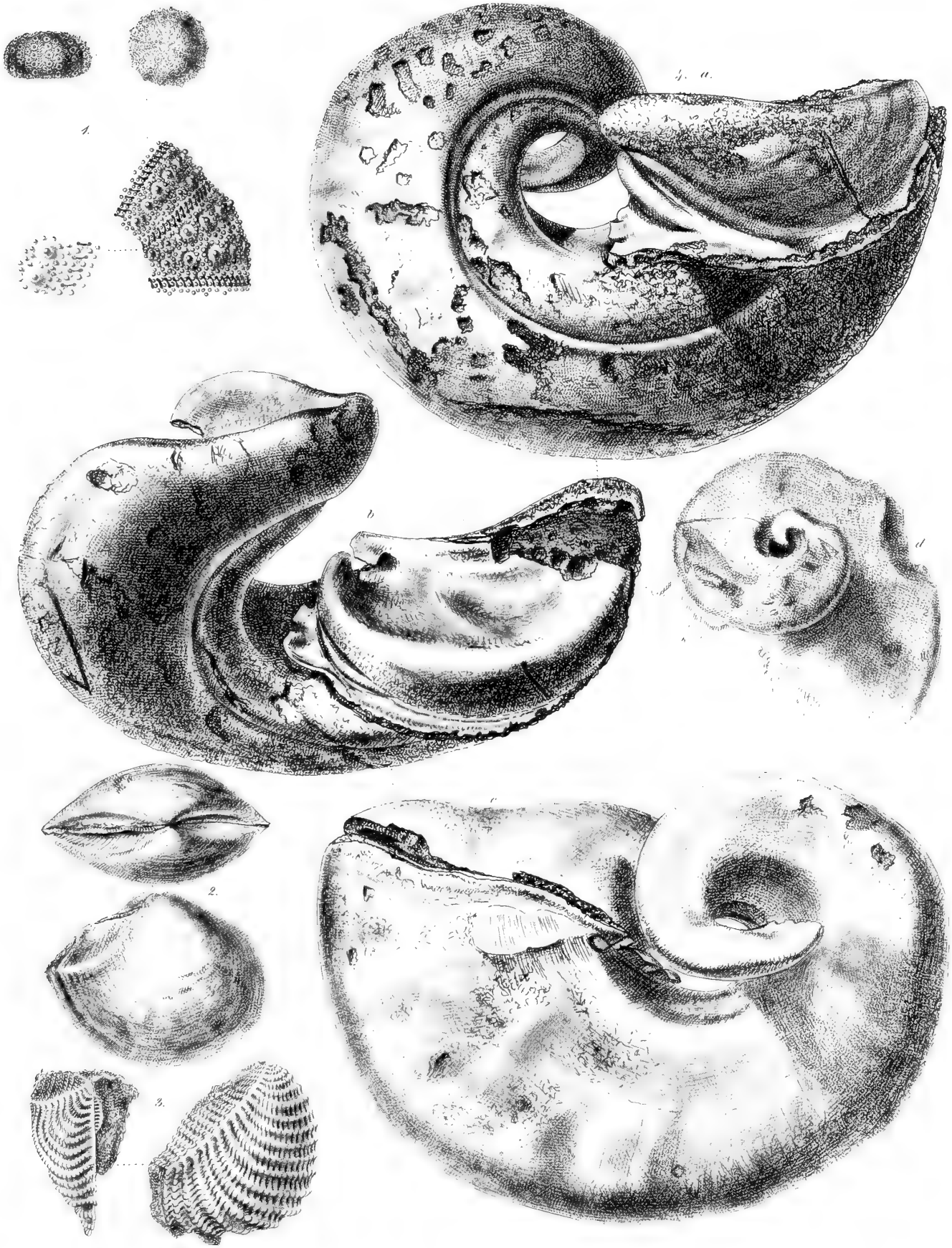








LOWER GREENSAND.



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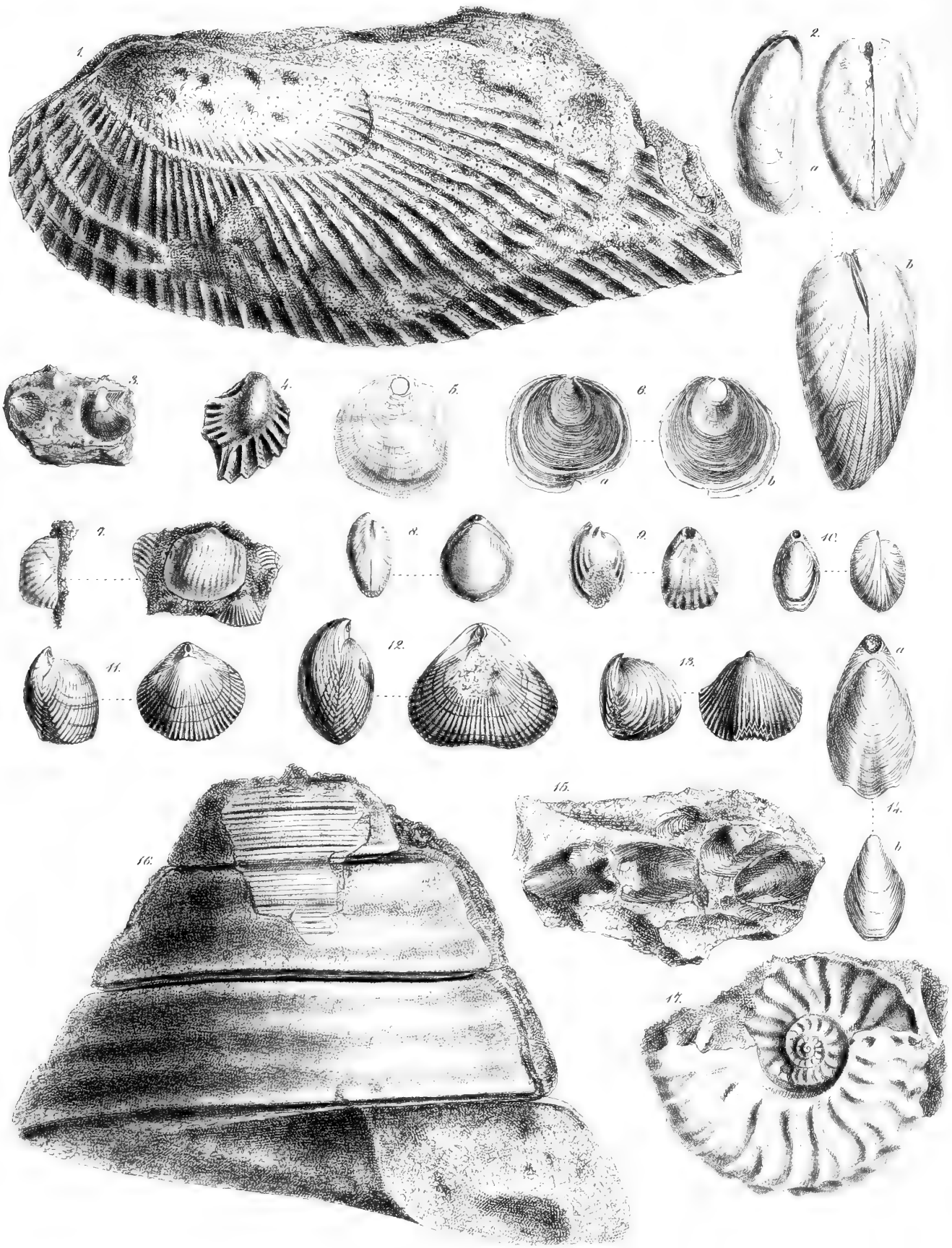
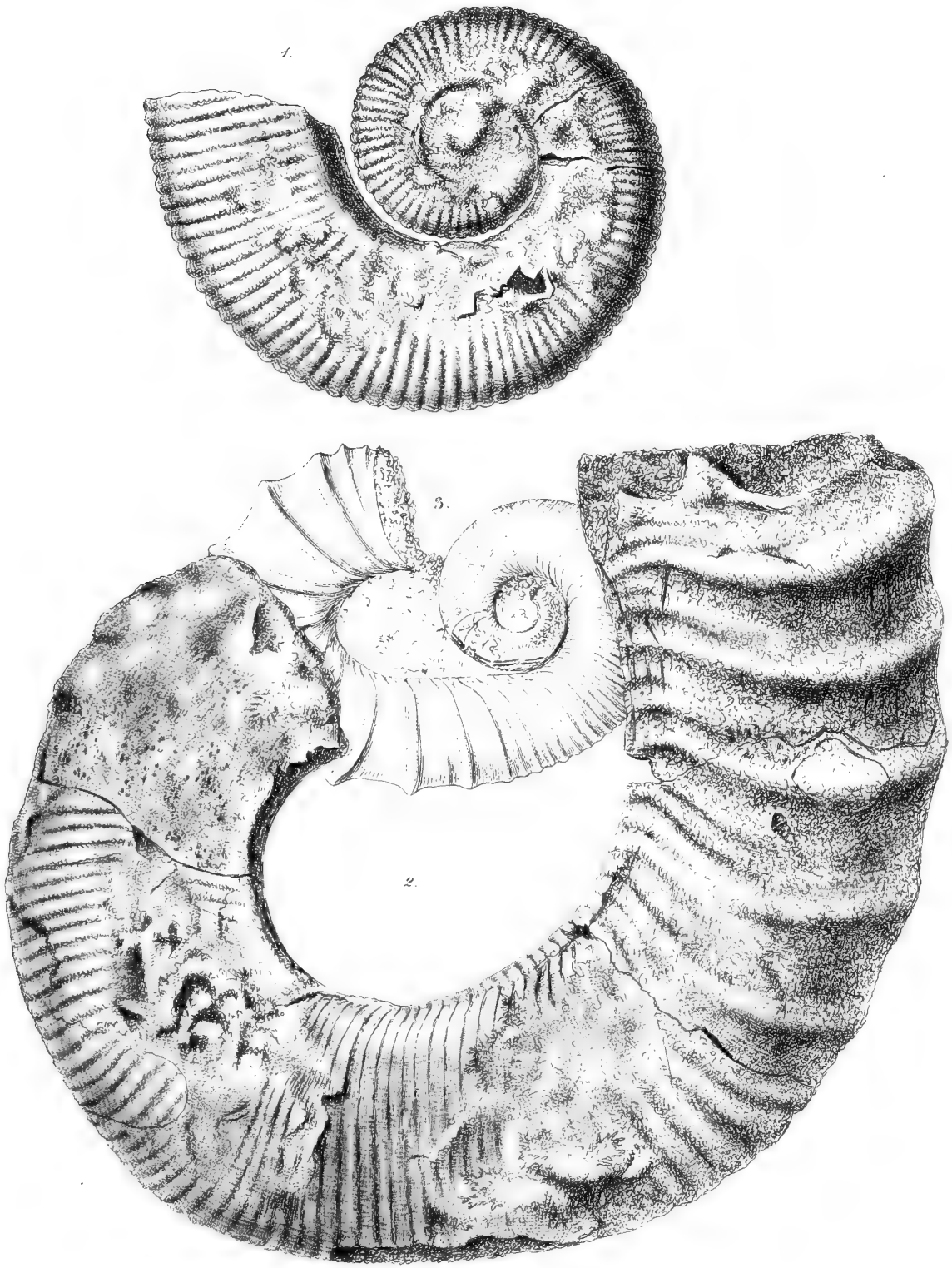
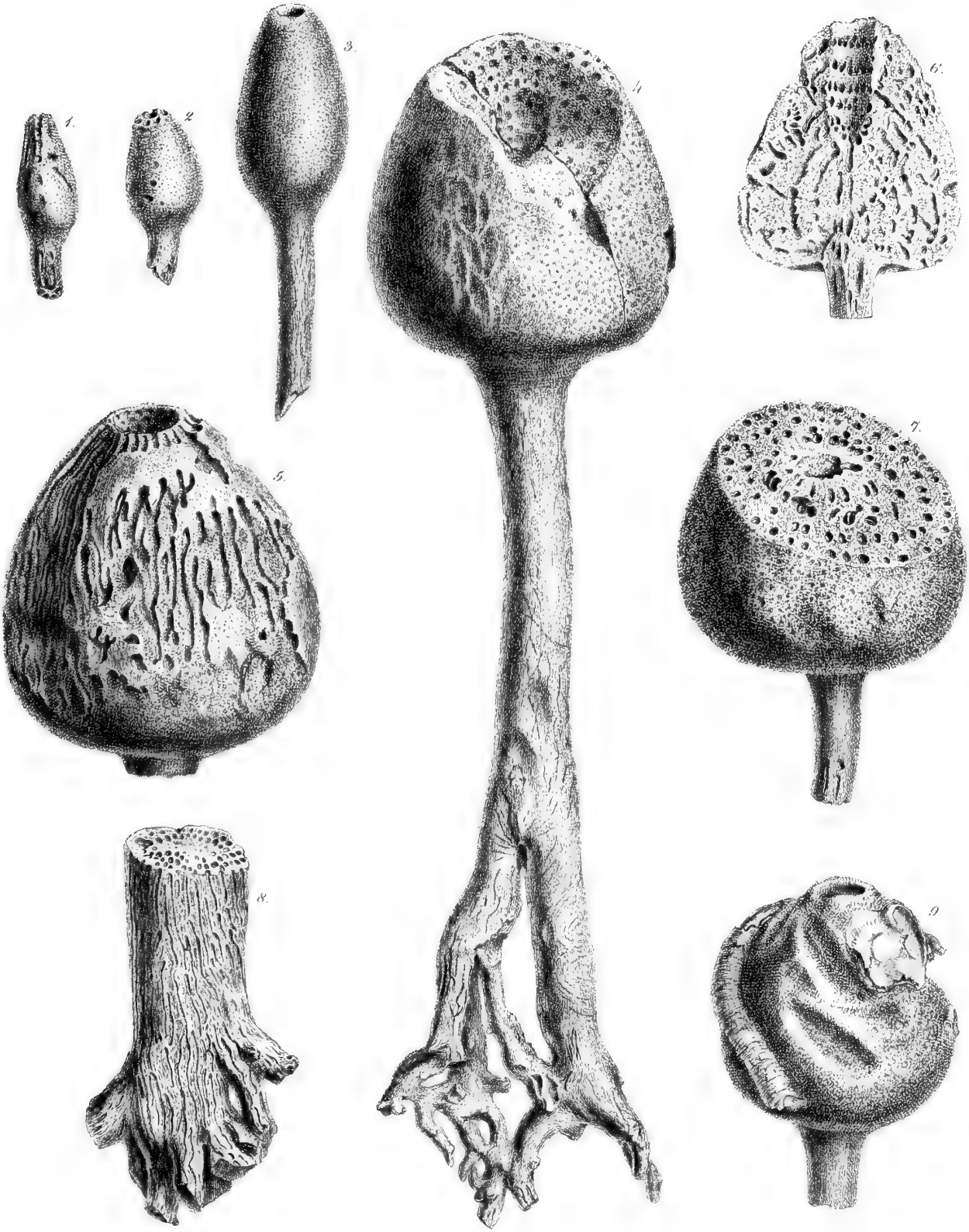
LOWER GREENSAND (continued)



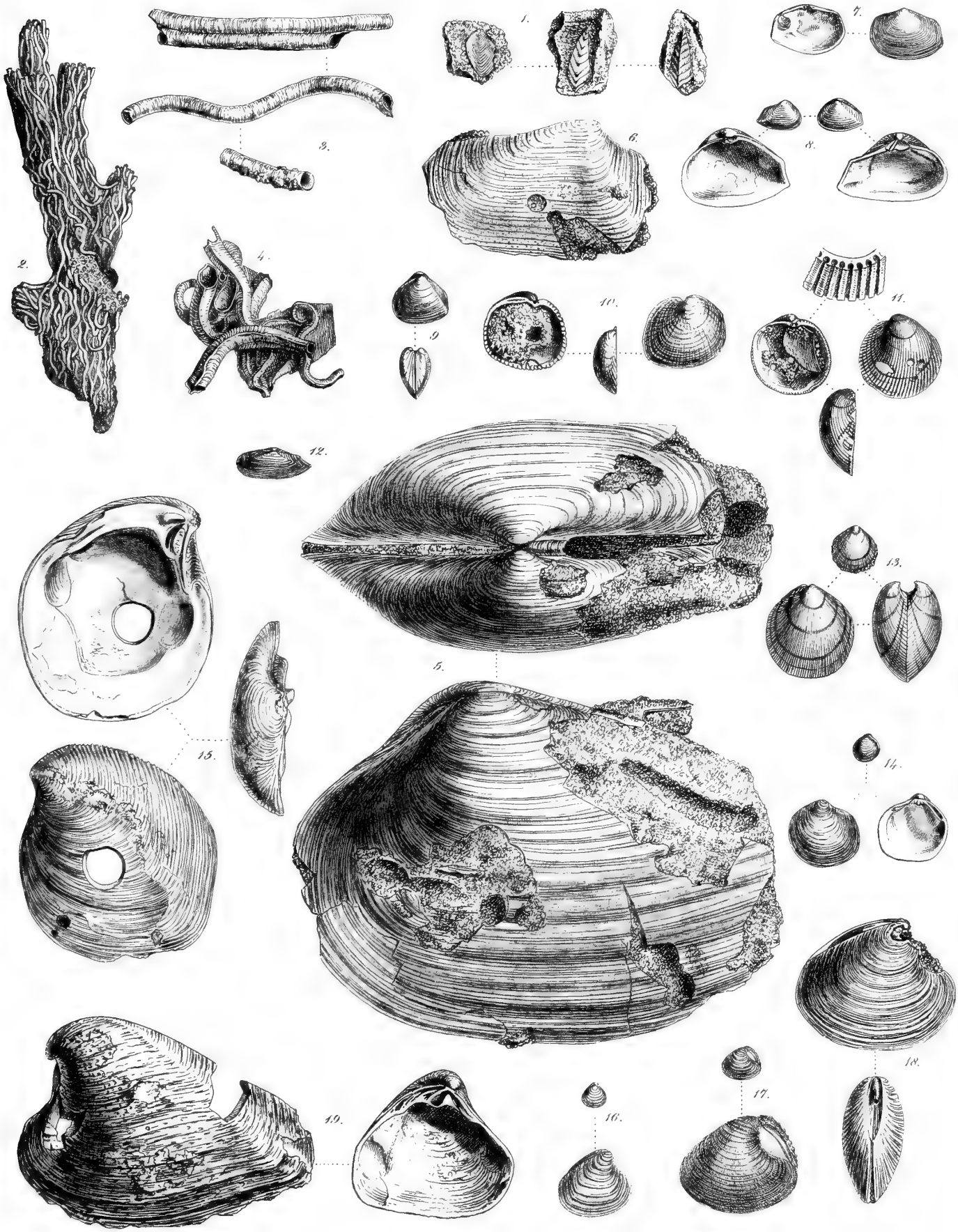
LOWER GREENSAND (continued.)



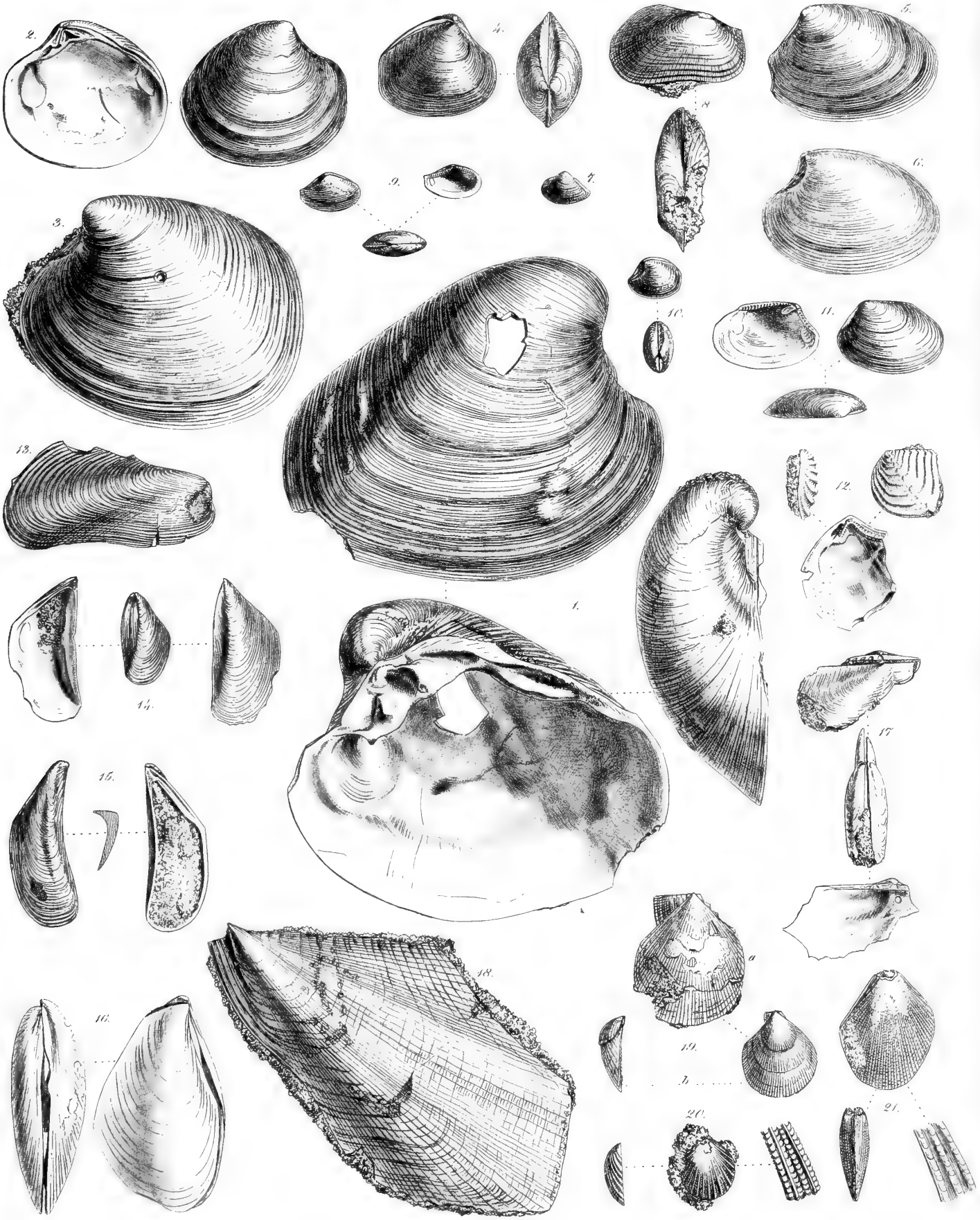
GREENSAND (of Blackdown, Devonshire)



GREENSAND (of Blackdown) continued



GREENSAND (or Blackdown,) continued



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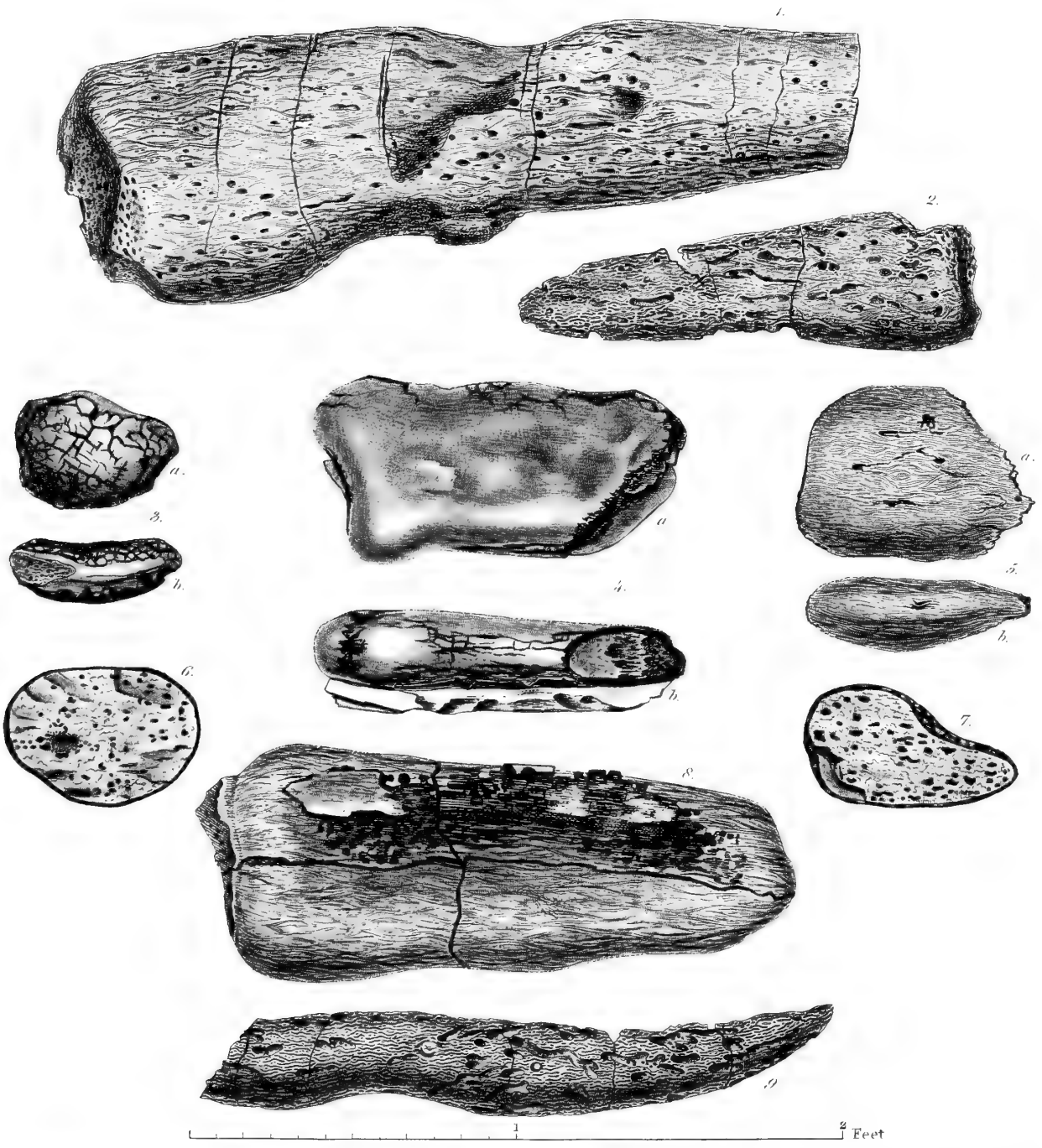
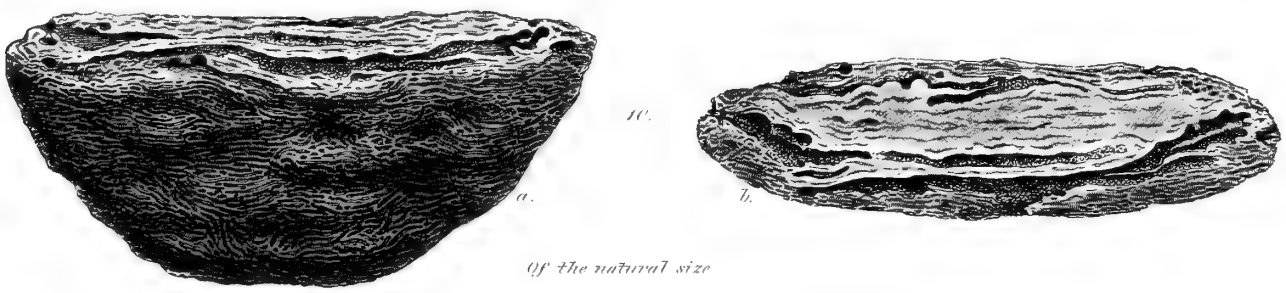
GREENSAND (of Blackdown) continued.

J.D.C. Sowerby fecit.

WEALDEN.

Endogenites erosa.





Of the natural size

WEALDEN.

Endogenites erosa.

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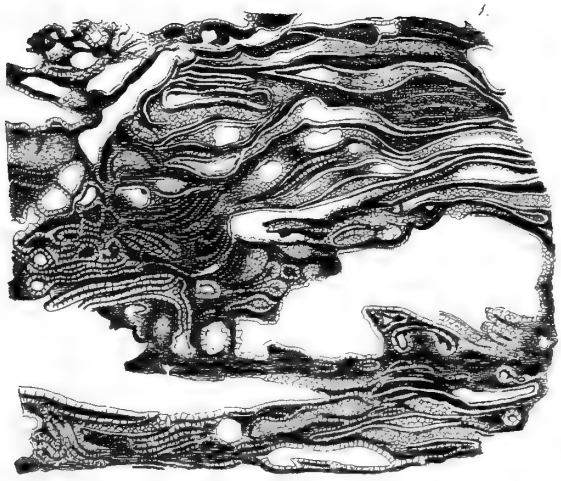

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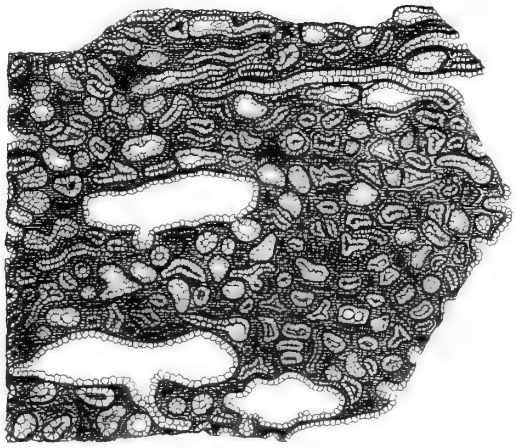

these two figures are magnified 4 times

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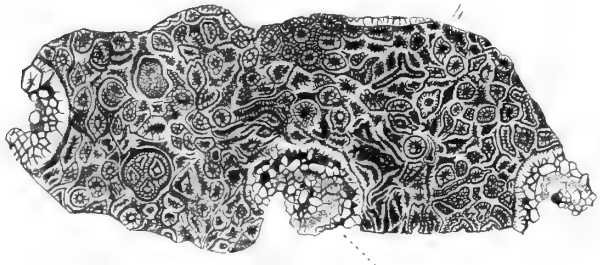

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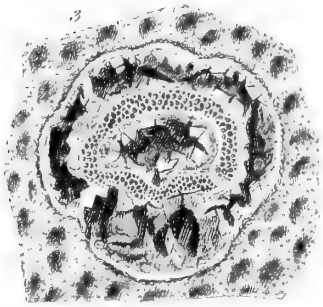

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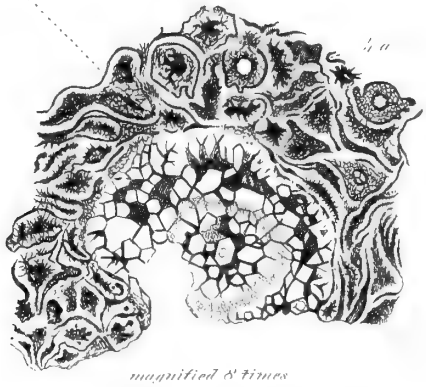
4 a



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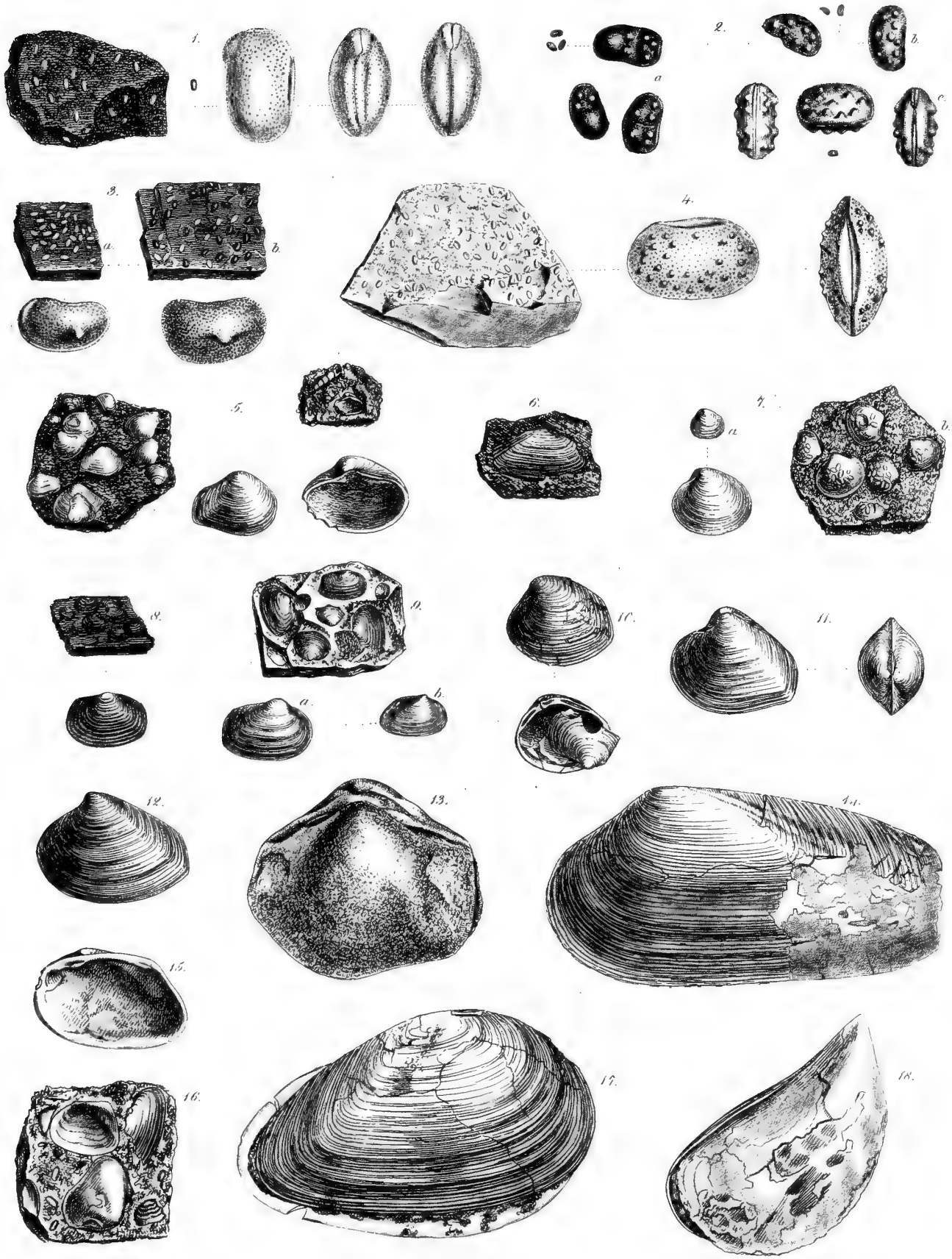
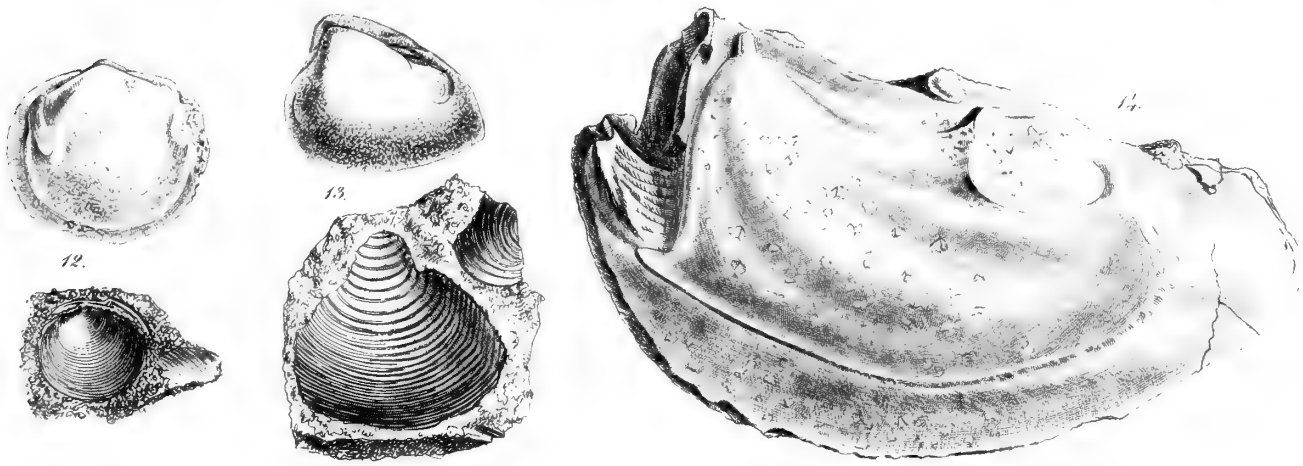


WEALDEN. (continued.)

PORTLAND.



PORTLAND (continued)

1.

2.

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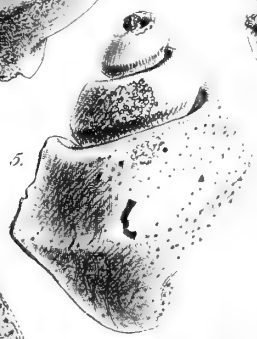
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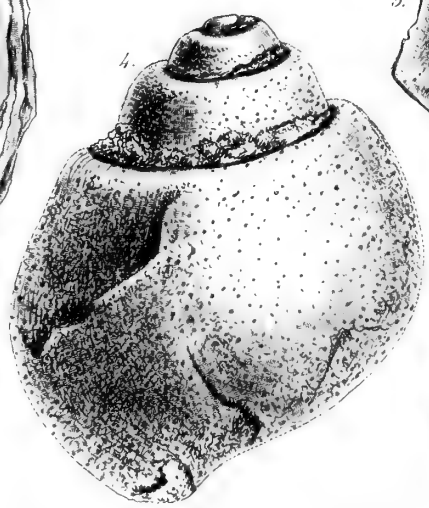
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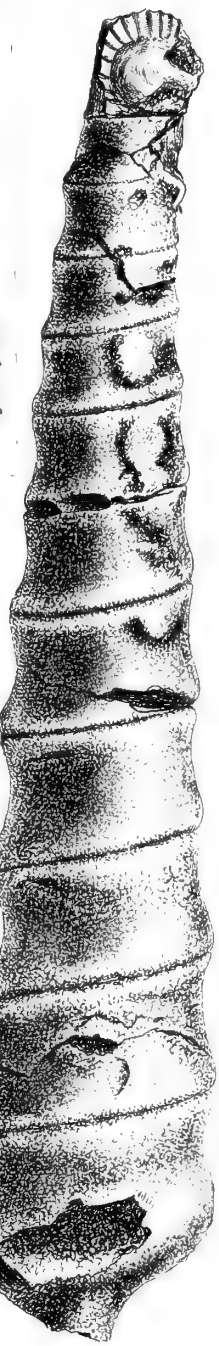
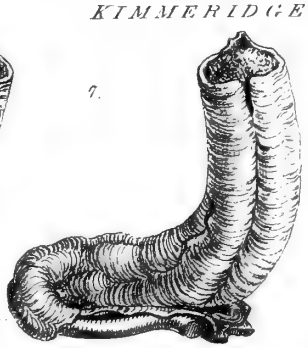


KIMMERIDGE & WEYMOUTH.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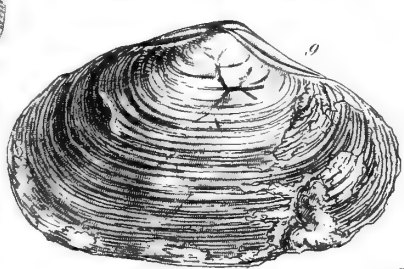
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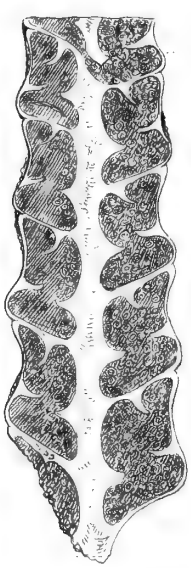
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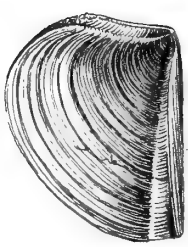

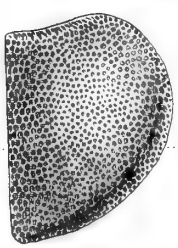

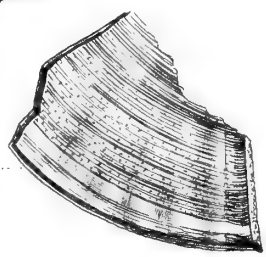
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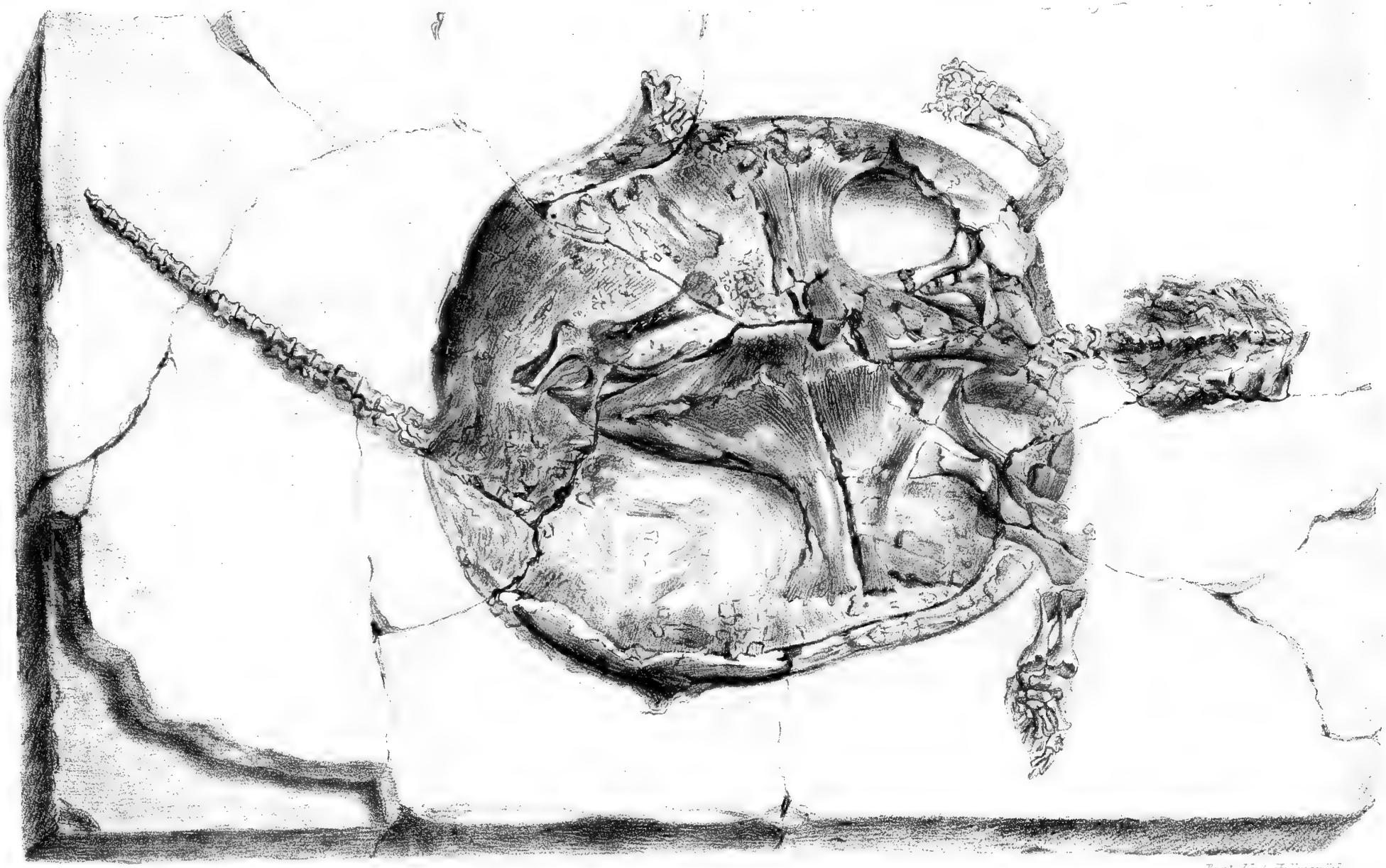


G Scharf lithog

Printed by C. Hullmandel

Chelydra Murchisonii.

FIG. 1. SECTION ON THE COAST OF CUMBERLAND BETWEEN PARTON AND St. BEES HEAD; p. 391 393.

Fig. 2 p. 383. 390.

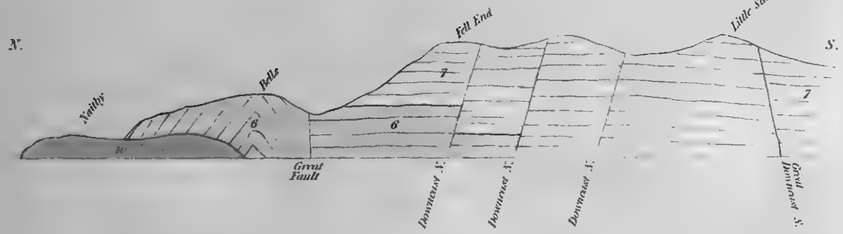


Fig. 3. p. 386.

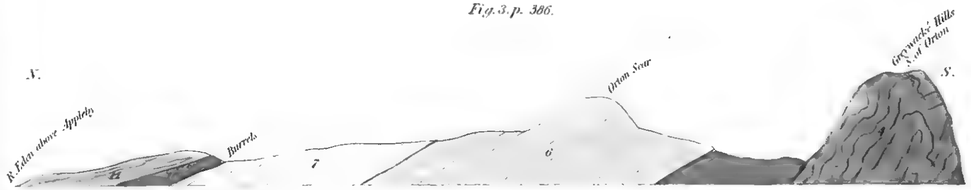


Fig. 4. p. 388.

Fig. 5. p. 389. 391.

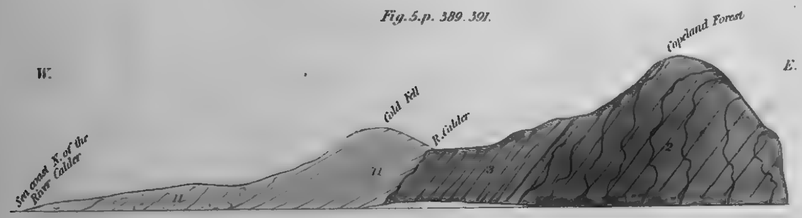
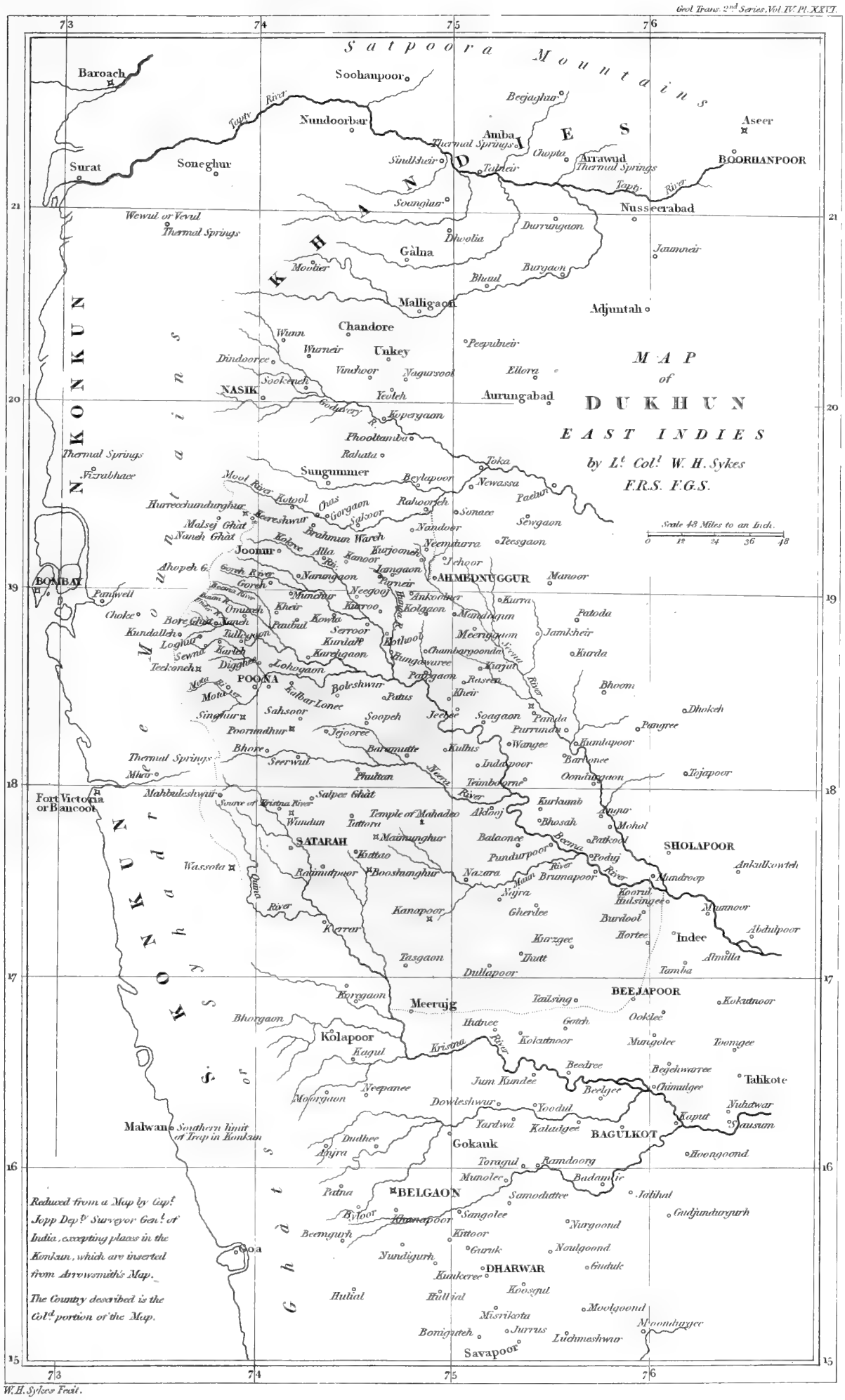


Fig. 6. p. 389 391

Fig. 7. p. 389.

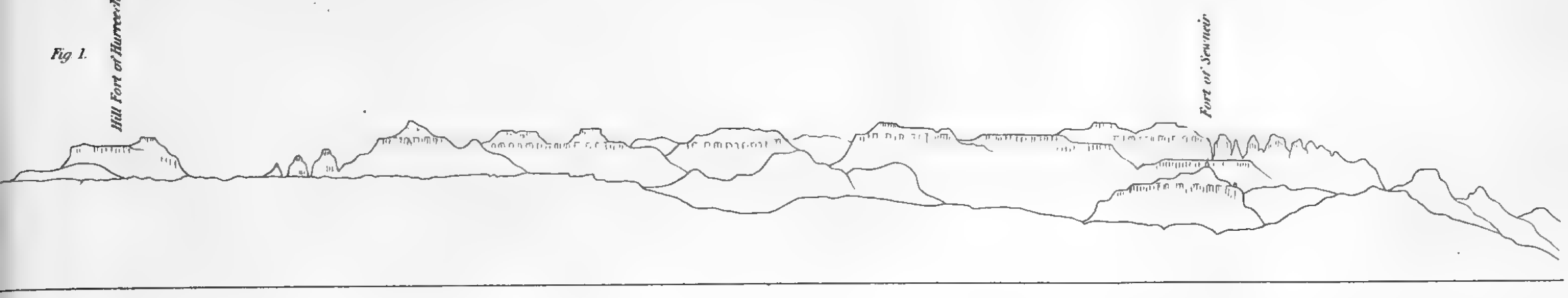
1. Granite
2. Skiddaw Slate (lowest Cumbrian Slate)
3. Green Slate & Porphyry (middle series)
4. Upper Slate Group.
5. Old red Sandstone & conglomerate.
6. Carboniferous Limestone (lower division)
7. Carboniferous Limestone (upper division)
8. Coal Measures
9. Lower New Red Sandstone.
10. Magnesian Limestone.
11. New Red Sandstone resting on gypseous Marls



W.H. Sykes Fecit.

RANGE OF HILLS N. AND W. OF JOONUR FROM THE SUMMIT OF A HILL N. OF THE TOWN OF GOREH.

Fig. 1.



N. TO E. RANGE OF HILLS AS SEEN FROM LAKUNGAON IN THE VALLEY OF JOONUR.

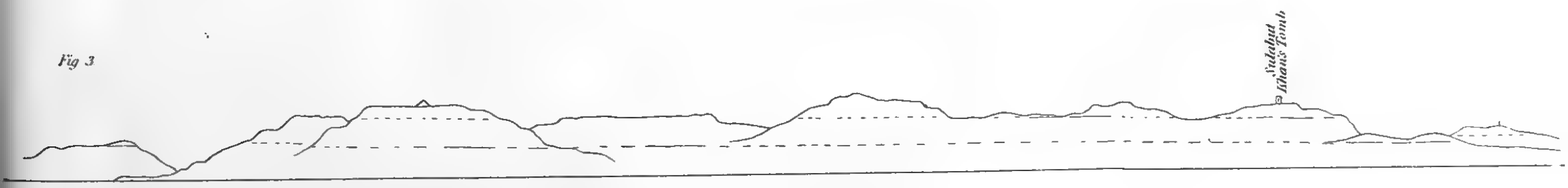
Fig. 2.

Fig. 2. CONTINUED FROM THE N. TO THE W.

Fig. 2*

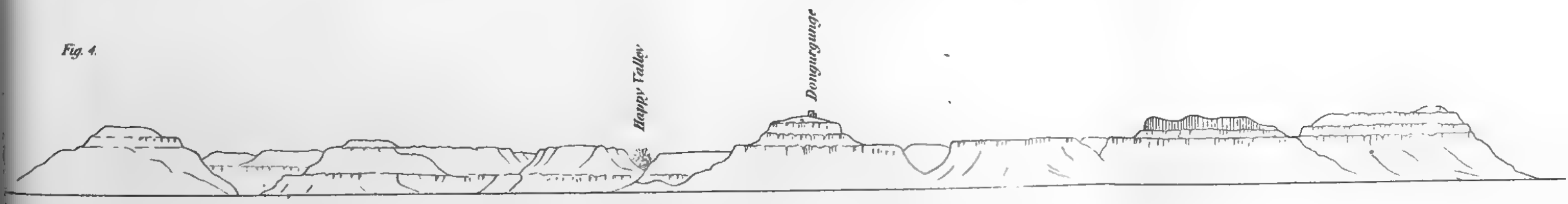
HILLS TO THE N.E. AND E. AS SEEN FROM THE ARMOURY IN THE FORT OF AHMEDNUGGUR.

Fig. 3.



NORTHERN FLANK OF THE PLATEAU ON WHICH THE CITY OF AHMEDNUGGUR STANDS AS SEEN FROM WAMOOREE.

Fig. 4.



Sketched by L. S. Fidler

Fig. 1. ELEVATION AND DECLINATION OF THE COUNTRY ABOVE THE GHÂTS, BETWEEN 73°.35. AND 74°.49. EAST LONGITUDE, AND THE PARALLELS OF 18°.50. AND 19°.10.31. NORTH LATITUDE: SHEWING THE GEOLOGICAL STRUCTURE, OF THE SAME.

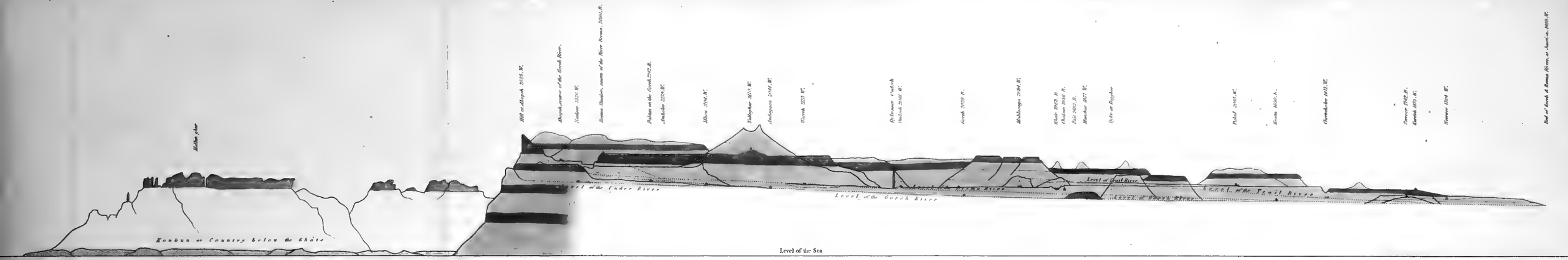
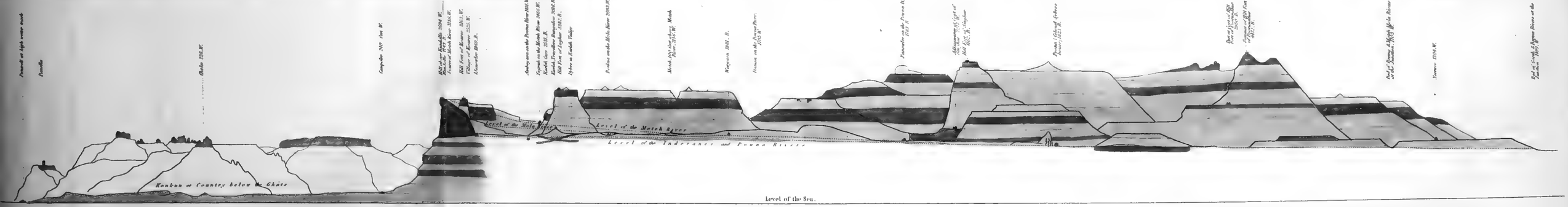


Fig. 2. ELEVATION AND DECLINATION OF THE COUNTRY ABOVE THE GHÂTS, BETWEEN 73°.35. AND 74°.49. EAST LONGITUDE, AND THE PARALLELS OF 18°.28. AND 18°.50. NORTH LATITUDE: SHEWING THE GEOLOGICAL STRUCTURE OF THE SAME.

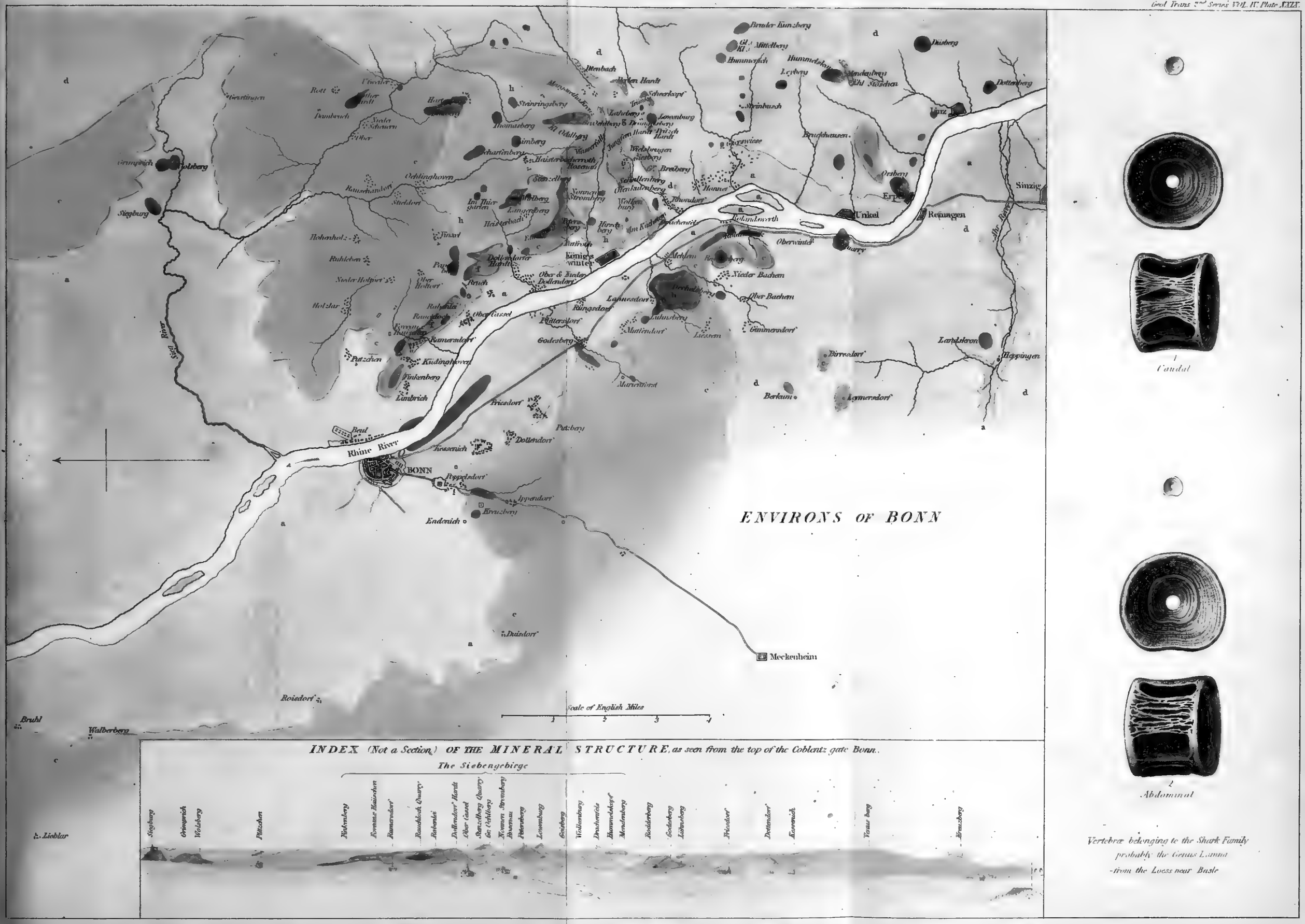


W. H. Sykes. fecit

The strata of the darker hue are Basalt of various kinds: those colored grey-green are varieties of Amygdaloid, quartz, zeolite, red cellular Rock

The letters following the numbers subjoined to the names of Places, denote the mode in which the heights have been obtained

B. simultaneous Barometric measurement. W. calculation from the temperature of boiling Water



1
Caudal

2
Abdominal

Vertebræ belonging to the Shark Family probably the Genus Lamna from the Loess near Basle

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